China Belt and Road Initiative

Measuring the impact of improving transport connectivity on international trade in the region – a proof-of-concept study

Hui Lu, Charlene Rohr, Marco Hafner, Anna Knack

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Preface

This project aims to gather evidence on the potential impact of multimodal transport infrastructure and connectivity on international trade under the China Belt and Road Initiative (BRI). The project consists of two main tasks: (i) a review of barriers to and facilitators of transport infrastructure and connectivity on trade in the BRI context; and (ii) an empirical structural gravity model analysis to quantify the potential impact of removing the identified barriers on international trade. The model results are then extrapolated to a series of policy scenario tests. The study may be of interest to policymakers and stakeholders who are interested in the Asia Pacific region and transport infrastructure investment.

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For more information, contact

Hui Lu
RAND Europe
Westbrook Centre
Milton Road
Cambridge CB4 1YG
United Kingdom
Tel. +44 (1223) 353 329
hlu@rand.org

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Background

In 2013, Chinese President Xi Jinping announced plans to build a Silk Road Economic Belt and a 21st Century Maritime Silk Road, which have come to be known as the Belt and Road Initiative (BRI). The BRI is geared towards encouraging greater connectivity, economic flow, the growth of job opportunities, investment, consumption, cultural exchange and the spirit of regional cooperation between Asia, Europe and Africa by creating jointly built trade routes emulating the ancient Silk Road. The colossal scale of the BRI is exemplified by the 4.4 billion people and the cumulative gross domestic product (GDP) of around US$21 trillion that it is set to encompass.

Whereas most literature focuses on the potential geostrategic impetus behind the BRI, this study focuses on gathering evidence on the potential impact of improving multimodal transport connectivity on multilateral trade and economic growth.

Main research question

Our primary research question is: **what is the impact of improving multimodal transport connectivity on multilateral trade and economic growth in countries and regions across the BRI**? To answer the research question, we undertake both qualitative and quantitative analysis.

Key findings

The findings of the literature review show that multimodal transport infrastructure and connectivity is key to boosting international trade and economic growth. More specifically, better transport infrastructure and connectivity can facilitate trade expansion, attract foreign direct investment, speed up the industrialisation process and enable more efficient production networks, facilitate regional integration and accelerate the process of economic growth and poverty reduction.

We identify key facilitators of and barriers to transport connectivity to facilitate multilateral trade in the general BRI context. Many barriers could become facilitators, if resolved. We broadly categorise these into two types: physical and soft barriers/facilitators. Physical barriers could include inadequate capacity of infrastructure and equipment, speed and cost of transporting goods or topographical factors such as deserts or mountainous regions. Soft barriers could

include legal and regulatory barriers, project financing and security, (inhospitable) terrain and security surrounding trade routes. We also discuss the role of technology in facilitating supply-chain resilience and resource efficiency. Overall, the BRI holds great promise to boost trade and economic growth but several barriers will need to be converted into facilitators. The outputs from the qualitative analysis are used to form the factors to be included in the second-stage quantitative model development.

In the second stage, we model the relationship between transport connectivity and transport infrastructure and multilateral trade and economic growth. We develop an econometric model to quantify the impact of improving transport connectivity on aggregate multilateral trade between areas covered by the BRI and the rest of the world. A series of indices are defined to measure transport infrastructure including rail density, road density, airport density, maritime logistics performance and overall logistics performance. To measure transport connectivity, bilateral distances between countries by rail, aviation and maritime transport are used, which provide a proxy for transport costs by each mode. Descriptive analysis shows that transport infrastructure and connectivity is generally lower in the BRI region compared to the other regions (European Union [EU] and elsewhere). Because of a lack of data (and limitations in the study budget and timescales), we are restricted to the development of a preliminary gravity model (Anderson and van Wincoop 2003, 2004). From the analysis we find that:

- There is a positive and statistically significant association between transport infrastructure and connectivity and bilateral trade. (We emphasise that at this stage what we find is an association only and the level of existing data is not sufficient to prove a causal relationship.) In the BRI region, the existence of a rail connection between trading partners is associated with a large impact on improving trade, e.g. improving total exports by 2.8 per cent in the BRI region, including the wider region. The second-most significant impact was brought by improvements in road density. In addition, transport service quality is found to have an important impact on bilateral trade.
- Our statistical inference suggests that, with the proposed level of investment in transport infrastructure in the BRI region, total trade volumes could increase not only in the BRI region, but also in areas outside the initiative (such as the EU). Therefore, improving transport infrastructure would appear to present a win-win scenario in terms of the impact on trade.

Caveats and potential future research

As noted above, given that the study was limited to simple gravity model formulations to quantify the relationship between transport infrastructure, connectivity and aggregate trade volumes, the current study would be improved by exploring this relationship across different economic sectors – agriculture, manufacturing, etc. The modelling would also be improved by refining the representation of transport costs and competitiveness across modes when such data are available, and by the use of panel data, in addition to cross-section data.

Further, the current model can only capture the static effects of improvements in transport infrastructure and connectivity, not the dynamic responses from producers, consumers and other economic parties. Ideally, this work should be extended using a Computable General Equilibrium (CGE) model to quantify the wider impact of transport improvement on trade and national economies. The modelling analysis could then explore a range of investment scenarios, further investigating the sensitivity of a wider range of assumptions.

Recommendations

We find that the BRI region suffers from having less developed infrastructure than other regions and that this hampers trade development. We recommend that investing in trade- and transport-related infrastructure such as ports, airports and road and rail links and connections should remain a priority and sufficient funding should be made available for this purpose.

Further, there could be substantial benefits if countries and regions across the BRI coordinate their development plans to achieve compatibility and complementarity between policies and infrastructure implementations. Countries should work together to ensure the initiative delivers sustained economic, social and environmental benefits across generations.

In addition to improving 'physical' transport infrastructure and connectivity, 'soft' barriers will need to be converted into facilitators. Legal and regulatory inconsistencies need to be addressed and streamlined across the BRI's overland and maritime corridors in order to reduce trade costs. Creating clear security arrangements and mechanisms to ensure the safety and security of goods travelling across the BRI can also help protect investments. Advancements in information and digital technology and automation can help improve multimodal transport connectivity by creating digital and information-sharing networks, collaborative platforms and opportunities to improve efficiency and supply-chain resilience.

This is a proof-of-concept study and targeted at stimulating discussion and providing empirical evidence on the order of magnitude of transport infrastructure improvements in the BRI region. We hope that the findings will be of use to policymakers and stakeholders who are interested in this infrastructure plan.

The objectives of this study

The objective of the CAPP China BRI study is to investigate the impact of improving multimodal connectivity and transport infrastructure on multilateral trade in the BRI context.

Our research methodology

Qualitative analysis: to identify the facilitators of and barriers to transport connectivity in relation to multilateral trade through desk study and expert interviews.

Quantitative analysis: to quantify the impact of improving transport connectivity and infrastructure on multilateral trade and economic growth in the BRI region using a structural gravity model.

Our evidence

(see main text for details)

We identified barriers and facilitators in transport connectivity and trade in the BRI context which include:

- Physical barriers (infrastructure gaps, speed and cost of transporting goods, etc.).
- Soft barriers (legal, regulatory, project financing, securities, etc.).

Barriers could become facilitators, if resolved.

We found that:

- The BRI region has lower levels of transport connectivity and infrastructure compared to other regions.
- Within the BRI region, there is substantial variation across countries.
- Poor infrastructure hinders international trade in this region.

Transport infrastructure was found to have a positive impact on trade:

- Improvement in infrastructure (roadway density and railway density) is associated with increased exports.
- Logistics performance (transport service quality) also plays a role in trade facilitation.

Transport connectivity was found to have a positive impact on trade:

- Having a rail connection is associated with the largest impact in the BRI (associated with increases in exports of 3%).
- Followed by reduction in aviation and maritime distances (as proxy of transport cost).

Simulation results show that with improvement of transport infrastructure, total trade volumes increase not only in the BRI region but also in the EU and elsewhere. Therefore, it presents a win-win scenario across the regions.

Conclusions

A series of barriers to and facilitators of trade are identified in relation to transport infrastructure in the BRI context. We find that the BRI region suffers from having less developed infrastructure than other regions and this hampers trade development. Through an empirical analysis using a structured gravity model and counterfactual simulation tests based on data from countries across the BRI, in the EU and elsewhere, we find that improvements in transport infrastructure could improve international trade both within the BRI region and with countries outside it. We recommend that investing in trade- and transport-related infrastructure such as ports, airports and road and rail links and connections should remain a priority. Further, there could be substantial benefits if countries and regions across the BRI coordinate their development plans. However, there also exist many ‘soft’ barriers that need to be addressed to further facilitate trade and stimulate economic growth in the region.

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Abbreviations

ADB	Asian Development Bank
AIIB	Asian Infrastructure Investment Bank
BRI	Belt and Road Initiative
BRICS	Brazil, Russia, India, China and South Africa
COMTRADE	UN Commodity Trade Statistics Database
DLT	Distributed Ledger Technology
EU	European Union
GDP	Gross Domestic Product
GQ	Golden Quadrilateral
LPI	Logistics Performance Index
LSCI	Liner Shipping Connectivity Index
MTR	Multilateral Trade Resistance
OLS	Ordinary Least Squares
PPML	Poisson Pseudo-Maximum Likelihood
SAARC	South Asian Association for Regional Cooperation
SDGs	Sustainable Development Goals
TAR	Trans-Asia Railway
TRAINS	Trade Analysis Information System
UNCTAD	United Nations Conference on Trade and Development
UNDP	United Nations Development Programme

1 Introduction

1.1. Background

The Belt and Road Initiative (BRI), China's vision of an economic belt fashioned after the ancient Silk Road, could have a profound impact on regional economic development across Asia, Europe and Africa. The colossal scale of the BRI, which comprises both an overland Economic Belt and a Maritime Silk Road, is exemplified by the 4.4 billion people and the cumulative gross domestic product (GDP) of around US$21 trillion that it is set to encompass (Rolland 2015). Such grandiose transport infrastructure projects are not unprecedented, with examples for instance during the American Gilded Age, when the construction of railroad lines unified a disparate patchwork of territories, decreasing the cost of transport, catalysing the spread of new products and opening opportunities for the exploitation of natural resources (Rolland 2015). Similarly, the ambitious Baghdad Railway, envisaged to run through Turkey and Mesopotamia, bypassing the maritime chokepoint of the Suez Canal up to the Indian Ocean, was full of the promise of accelerated trade and economic growth between Europe, the Ottoman Empire and the Far East – until Britain curtailed the project, threatened by German encroachment on Britain's dominion over the Indian Ocean (Brewster 2017). Improvements in transport infrastructure can have positive effects on development through the levelling effects of roads and the facilitation of trade through transport nodal points such as ports (Estache and Garsous 2012). Additionally, improvements in the quality and quantity of infrastructure are positively correlated with the boosting of human and physical capital which, in turn, leads to growth (Mayaki 2017).

The Belt and Road Initiative (BRI)

In 2013, Chinese President Xi Jinping announced plans to build a Silk Road Economic Belt and a 21st-Century Maritime Silk Road, which have come to be known as the Belt and Road Initiative (previously known as 'One Belt, One Road'). The BRI is geared towards encouraging connectivity, economic flow, job opportunities, investment and consumption, cultural exchanges and the spirit of regional cooperation between Asia, Europe and Africa by creating jointly built trade routes emulating the ancient Silk Road. The Silk Road Economic Belt connects China, Central Asia, Russia and Europe, and the 21st Century Maritime Silk Road runs along China's coast towards Europe in one direction and from China's coast, cutting through the South China Sea and the South Pacific, in the other. The overland path will leverage existing international transport routes and key economic industrial parks as springboards for cooperation, while the sea route aims to build transport routes bridging major sea ports across the BRI. The project will be multilaterally funded by the Chinese-led Asian Infrastructure Investment Bank (AIIB), the Brazil, Russia, India, China and South Africa (BRICS) New Development Bank and private institutions, so running parallel to the infrastructure development are initiatives aimed at promoting financial integration and cooperation.

Overall, 65 countries across the BRI will have a stake in the ambitious project. These are: China, Mongolia, Brunei, Cambodia, Indonesia, Laos, Malaysia, Myanmar, Philippines, Singapore, Thailand, Timor-Leste, Vietnam, Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan, Uzbekistan, Bahrain, Egypt, Iran, Iraq, Israel, Jordan, Kuwait, Lebanon, Oman, Qatar, Saudi Arabia, Palestine, Syria, United Arab Emirates, Yemen, Afghanistan, Bangladesh, Bhutan, India, Maldives, Nepal, Pakistan, Sri Lanka, Albania, Armenia, Azerbaijan, Belarus, Bosnia and Herzegovina, Bulgaria, Croatia, Czech Republic, Estonia, Georgia, Hungary, Latvia, Lithuania, Macedonia, Moldova, Montenegro, Poland, Romania, Russia, Serbia, Slovakia, Slovenia, Turkey and Ukraine.

Source: Chin and He (2016); The State Council of the People's Republic of China (2017)

Rather than a singular route, as the name might suggest, the BRI is composed of six major economic corridors (see Figure 1). These are the New Eurasian Land Bridge and corridors through China–Mongolia–Russia, China–Central Asia–Western Asia, the Indo-China Peninsula, China–Pakistan and Bangladesh–China–India–Myanmar (Das 2017). These corridors will be made up of networks of rail routes, roads, waterways, pipelines and information highways that link industrial and energy clusters (Das 2017), and will contain both an overland and a maritime component. The BRI is also made up of two tiers: an international and an interior, relating respectively to infrastructure projects undertaken with neighbouring countries and those undertaken within China's interior regions (Das 2017).

The BRI's projects are and will be mainly taking place in regions that suffer from a shortage of infrastructure investment funding. According to figures provided by the Asian Development Bank (ADB), the fast-growing regions in Asia (such as Southeast Asia) will need an estimated US$8.22 trillion (Bhattacharyay et al. 2012) of infrastructure investment for the current decade. The BRI will partially solve this funding gap and thus will be beneficial to the regions that most need funding.

Although such efforts are not unprecedented, other previous transport and economic corridor projects between Europe and Asia – such as the Transport Corridor Europe–Caucasus–Asia

Figure 1 Map of BRI regions and projects

Source: Mercator Institute for China Studies. (C.Inton, 24/03/2017. Reuters)

(TRACECA) or the Central Asia Regional Cooperation (CAREC) Program – have not been ascribed the same potential as the BRI, which can perhaps be attributed to poor coordination (Nazarko et al. 2016).

Another strength of the BRI, in contrast to its predecessor projects, is the institutional framework supporting it. This includes the new Asian Infrastructure Investment Bank (AIIB) and the Silk Road Fund (SRF), the European Bank for Reconstruction and Development (EBRD), which China has recently joined (Nazarko et al. 2016), the Brazil, Russia, India, China and South Africa (BRICS) New Development Bank and the proposed Shanghai Cooperation Organization Bank (Lim 2015). The AIIB is predominantly funded by China but with the help of regional and non-regional stakeholders (Das 2017). A positive aspect of the AIIB, in comparison to other, more established international financial institutions such as the ADB and the World Bank, is its willingness to finance infrastructure projects for which it would normally be difficult for low-income countries to secure funding from the Bretton-Woods institutions (Lim 2015). Furthermore, the AIIB will also allow private-sector involvement in its projects, with the aim of minimising state borrowers' public debt (Lim 2015).

China's ambitious BRI project aims to use connectivity to boost international trade and economic growth; however, whereas most literature[1] on the BRI focuses on the potential geostrategic impetus behind it, this study focuses on gathering evidence on the potential impact of improving multimodal transport connectivity on multilateral trade and economic growth.

1.2. Objectives and scope of this study

Our primary research question is: **what is the impact of improving multimodal transport connectivity on multilateral trade in countries and regions across the BRI**? To answer this question, we undertake both qualitative and quantitative analysis. First, through document review and expert interviews, we identify potential facilitators of and barriers to transport connectivity to facilitate multilateral trade. The outputs from this task identify factors to be included in the quantitative model development.

Second, an econometric model framework is developed to quantify the impact of improving transport infrastructure and connectivity on aggregate multilateral trade across BRI regions. Due to lack of data, we are restricted to the use of preliminary gravity models (Anderson and van Wincoop 2003, 2004). The study area covers countries within the BRI, countries in Europe and a few other countries.

Readily verifiable data from publicly accessible sources, for example World Bank country economic data, UN Commodity Trade Statistics Database (COMTRADE) bilateral trade data, United Nations Conference on Trade and Development (UNCTAD) Trade Analysis Information System (TRAINS) tariff data and CEPII distance data and data on other country characteristics, is used to develop the gravity models.

The model is then discussed and extrapolated to a series of policy scenario tests (for instance infrastructure improvement) to forecast the potential impact of improving multimodal connectivity and transport infrastructure on trade and economic growth in the BRI region and the wider economies.

1.3. Structure of this report

The report is organised as follows. In section 2, we provide a brief literature review on the importance of transport infrastructure and connectivity for trade and economic growth. In section 3, barriers to and facilitators of transport connectivity and trade in the context of the BRI are identified and measures to address the barriers are briefly discussed. To model the impact of transport infrastructure on trade, in section 4, we describe particular measures related to transport infrastructure and connectivity. In section 5, the empirical model results are reported with scenario simulation tests. Finally, section 6 discusses our research findings and potential policy implications.

1 See, for instance, van der Putten (2017) for a review of the relation between China and EU member states in the context of the BRI.

2 The impact of multimodal transport infrastructure and connectivity on trade and economic growth

The influence of transport infrastructure on international and regional trade and its economic benefits are widely documented (see Behar and Venables 2010; Redding and Turner 2014 for a review). In this chapter we set out some of the key pathways between improved transport connectivity and economic benefits, as identified in both theoretical and empirical literature.

2.1. Good transport infrastructure reduces the cost of transport and facilitates trade expansion

2.1.1. Good transport infrastructure reduces transport costs

In international trade theory, transport costs were introduced to explain the differences between traded and non-traded commodities (Samuelson 1954). Such costs might be expected to depend on geographical factors and can, therefore, be treated as an exogenous variable of the trade in trade models. However, it is also plausible that transport costs may depend (inversely) on the quality of transport infrastructure. Thus, differences in the quality of infrastructure across countries may explain differences in transport costs, which in turn may be able to account for differences in competitiveness.

In trade literature, transport costs can be manifested in several dimensions. First, they can reflect a **direct measure of the cost** for a given mode of transport (rail, road, etc.), measured as costs per mile or kilometre. A rich literature documents a decline in direct transport costs for goods over the past decades due to improvements in transport infrastructure. Hummels (1999) finds that the cost of air freight decreased by a factor of about 12.5 between the 1950s and the 2000s, while the cost of shipping remained approximately constant. Glaeser and Kohlhase (2004) find that rail costs decreased by a factor of about 8 over 110 years. Redding and Turner (2015) report a similar finding that the price per ton-mile of rail freight fell from about 18.5 cents in 1890 to 2 cents in 2000.

Second, transport cost can be impacted by the **quality of infrastructure**. Limão and Venables (2001) find that for coastal countries, national transport infrastructure accounts for 40 per cent of transport costs, while for landlocked countries, national and transit country infrastructure accounts for 60 per cent of transport costs. They find that improvements in road and rail infrastructure from the 25th to the 75th percentile would overcome more than half the disadvantage of being landlocked. Clark et al. (2004) find that the cost of maritime freight shipping to and from the United States is equal to about

5.25 per cent of the value of freight and that port efficiency is an important contributor to this cost. They estimate that deterioration in port quality from the 75th to the 25th percentile raises shipping costs by 12 per cent, equating to a 60 per cent increase in distance from markets.

The third dimension is **transport time**. This is particularly relevant if a company adopts 'just-in-time' practices and has an international supply network. Hummels et al. (2007) find that each day saved on journey times is equivalent to an average tariff reduction of approximately 0.4 to 1 per cent for exports and 0.8 to 1.5 per cent for imports. Delivery time is partly determined by the distance between trading partners but probably more importantly also by geography and infrastructure quality. For example, poor port infrastructure or inefficient port handling procedures may cause long delays that are not necessarily reflected in the monetary costs of transport services. Wilson (2003) calculates that the average time spent waiting at a border might be used to travel 1,600 km over land. Such delays can be due to physical infrastructure deficiencies at ports but can also be procedural.

The fourth dimension is the **opportunity cost** of access to good transport services. Lack of access to a good transport infrastructure can create barriers between those who are connected and those who are not. For example, in the manufacturing sector, good access to transport links can make it possible for factories to utilise cheaper land and labour. This is discussed more below (sections 2.2 and 2.3).

In summary, good transport infrastructure can reduce the cost of transport, reduce transport times and improve delivery reliability.

2.1.2. Transport costs have a significant impact on trade flow

Econometric studies have found that transport costs have a statistically significant impact on trade flows. Limão and Venables (2001), using both Cost Insurance and Freight(named port of destination) and Free on Board (named port of shipment) (cif/fob)[2] measures and freight rates, estimate the elasticity of trade with respect to freight costs to be in the range –2 to –3.5. Increasing transport cost from the median value to the 75th percentile in their sample therefore results in cuts of trade volumes by two-thirds. Using a similar methodology, Clark et al. (2004) estimate an elasticity of about –1.3 for country-specific freight transport costs. It should be noted that these studies are based primarily on the use of cross-section variation to identify the impact of freight costs on trade.

In the long term, reductions in transport costs have played a role in driving the growth of world trade. Baier and Bergstrand (2001) look at the determinants of trade growth in the periods 1958–60 to 1986–88 for 16 OECD countries and find an elasticity of trade with respect to the cif/fob ratio of –3, consistent with the cross-section findings above. They estimate the relative contributions of income growth (accounted for 66 per cent), trade liberalisation (for 26 per cent) and changes in transport costs (8 per cent) to the recorded growth of trade. Their estimates suggest that reductions in transport costs played a minor part in this growth. In total, the 34 per

2 The cif price measures the cost of the imported item at the point of entry into the importing country, inclusive of the costs of transport, including insurance, handling and shipment costs but not the customs charges. The fob price measures the cost of an imported item at the point of shipment by the exporter as it is loaded onto a carrier for transport. The higher the cif /fob ratio, the higher the share of transport cost in the value of added goods.

cent attributed to trade costs (i.e. transport costs plus trade policy restrictions) is consistent with the findings of Jacks et al. (2008). The latter study attributes 31 per cent of the 1950–2000 trade expansion to trade costs and calculates a much higher proportion (55 per cent) for the pre-First World War trade boom.

Despite estimating a similar elasticity, the results in Baier and Bergstrand (2001) suggest transport costs have a relatively minor role; however, those in Limão and Venables (2001) imply transport costs are very important. The contradiction could be explained by sample size differences between the two studies.

2.1.3. Good transport infrastructure facilitates trade expansion and attracts foreign direct investment

The empirical literature makes extensive use of gravity models (see Anderson 1979, 2011 for an overview) to investigate the impact of various measures of transport costs as well as other factors on trade flows (see Behar and Venables 2010 for a review). Gravity models follow a similar structure to Newton's Law of Universal Gravitation, hypothesising that bilateral trade flows are a function of the respective sizes of and the distance between two markets. Transport costs may better reflect the friction between markets, for reasons discussed above.

Nordas and Piermartini (2004) and Shepherd et al. (2011) use gravity models with transport costs to quantify the impact of transport infrastructure on trade flows. For instance, the latter study finds that a 5 per cent improvement in multimodal transport infrastructure would lead to an increase of between 2 and 5 per cent in trade in the OECD countries. However, it should be emphasised that in such a study identification of these relationships is challenging because of endogeneity issues, particularly the fact that transport infrastructure (such as roads/railway) is more likely to be built in places where economic demand and productivity are growing, so the impact of providing such infrastructure may be overstated more generally. Although the causality direction of transport infrastructure and trade growth remains a known challenge, previous studies find a positive association between transport infrastructure and trade expansion.

To summarise, transport infrastructure has been shown to have a significant impact on the reduction of transport costs, contributing to trade expansion. Next, we will investigate the impact of transport infrastructure improvement on wider economic benefits including industrialisation, regional economic integration and overall regional and national welfare.

2.2. Efficient transport infrastructure facilitates industrialisation

Previous literature suggests that improved transport infrastructure speeds up the industrialisation process and also enables more efficient regional and global production networks (Carruthers et al. 2003). In turn, this results in more employment generation, positively affecting industries and sectors.

Jacoby and Hodge (2008) summarise the benefits of better infrastructure to a company's operating costs as arising from lower resourcing costs, reduced fleet, warehousing and inventory cost savings and improved transit times.

Shirley and Winston (2004) find that highway infrastructure investment generates benefits by reducing firms' inventories. Datta (2012) shows that the upgraded Golden Quadrilateral (GQ) Project (a major highways project in India) allows Indian firms to hold inventory for shorter durations by between 6 to 12 fewer days. The reduction in stocks of input inventories varied inversely with the distance between the city in which the firm was located and the nearest city on an improved highway.

In the long run, firms may benefit from making input substitutes and reconfiguring production processes, thereby improving service and reducing cost. For instance, Gunasekera et al. (2008) find that better transport infrastructure improves producers' access to distant markets and allows them to draw inputs from a wider area, hence stimulating local production.

Gibbons et al. (2012) study the impact of new road infrastructure on firms in the UK, finding that a 1 per cent improvement in accessibility leads to about a 0.3–0.4 per cent increase in the number of businesses and employment. These effects tend to come from new rather than existing firms. The endogeneity problem (where roads are more likely to be built in places where demand and productivity is growing) is controlled for in the study by identifying the effects of changes in accessibility from variation across small-scale geographical areas close to the new road infrastructure.

Martincus and Blyde (2013) study how earthquakes in 2010 damaged roads in Chile and reduced exports for manufacturing firms that had to reroute their shipments. Controlling for endogeneity, their study highlights that infrastructure shortage can have a negative impact on firms' exports, thus limiting their ability to benefit from potential economies of scale and gains from trade in general.

Ghani et al. (2016) also study the impact of the GQ Project on manufacturing firms in India. Compared to the pre-period levels, the manufacturing activity output increased from US$1.8bn to US$3.8bn and 43 per cent of the observed increase could be attributed to the GQ updates. The study found that upgraded transport infrastructure encouraged new entrants to locate around the upgraded GQ network, with increases in total output, employment, wages and total factor productivity. Although incumbent firms benefited from the upgrades, a large part of the total impact came through the benefits to new entrants.

2.3. Better transport infrastructure and logistics support regional economic integration

Better transport infrastructure enables regions to be well connected, which in turn leads to the spatial distribution of economic activity. Empirical evidence on this has been established primarily using cross-country data (e.g. Limão and Venables 2001) but there is also single-country data, for instance regarding the construction of very large national transport networks in the United States (Baum-Snow 2007; Donaldson and Hornbeck 2015), India (Donaldson 2016), China (Banerjee et al. 2012; Faber 2014), Indonesia (Rothenberg 2013) and Brazil (Bird and Straub 2014). Rich literature, in different contexts, suggests that the improvement of transport infrastructure has an impact on the spatial distribution of economic activity; however, evidence on the pattern of the spatial distribution continues to present a mixed picture (see Redding and Turner 2014 for a comprehensive review).

Better transport networks might induce firms to locate outside of congested urban agglomerations, so that they can access cheaper land and labour while bringing more jobs to less developed regions. Improved logistics and supply chains could open up access to previously unreachable areas and link key economic centres in a region to national markets (Jacoby and Hodge 2008). The Pearl River Delta (Dossani 2016) provides an example of the successful development of economic corridors through a prior improvement of transport infrastructure (such as high-speed Rail, expressway and sea ports linking Hong Kong, Macau and major cities in Guangdong Province).

Baum-Snow (2007) studies how the US interstate highway system caused a suburbanisation of populations, while Baum-Snow et al. (2012) show how railroad expansions in China also encouraged cities to decentralise. Similar suburbanisation effects were found in Spanish cities using variation in distance from historical Roman highways (Garcia-Lopez et al. 2015). In other words, the research found population growth is higher the closer we move to the nearest highway ramp.

Using panel data and discrete choice modelling techniques, Rothenberg (2013) shows how road improvements in Indonesia affect the location decisions of firms and the spatial distribution of economic activity. The model controls for the endogeneity associated with firms' location choice. The simulation results show that new toll roads connecting the urban areas would lead to a modest amount of industrial suburbanisation.

On the other hand, better roads make firms in existing cities more profitable by bringing them closer to other markets. Therefore, lower transport costs could intensify the self-reinforcing home-market effects that cause market agglomerations, thus explaining regional economic divides. In the core–periphery model, Krugman (1991) suggests that reducing the costs of trade between two regions cause firms to agglomerate, pulling the entire manufacturing sector into one region. World Bank (2009) research finds that reductions in transport costs have coincided with greater economic concentration within countries, increasing the importance of trade with neighbours.

Venables and Limão (1999) find that transport costs may cause the world to be divided into 'zones of specialisation', where more transport-intensive goods are more likely to be exported by countries that have lower shipping costs to the economic centre. Faber (2014) shows that a national highway programme in China resulted in lower GDP growth and lower industrial output growth in non-targeted, peripheral counties affected by the highway. This study suggests that instead of promoting a diffusion of economic activity, highways may encourage spatial concentration and regional divergence.

2.4. Better transport infrastructure fosters development, aggregates regional and national welfare

Lastly, lower transport and trade costs can accelerate industrial agglomeration (Baldwin and Forslid 2000; Krugman 1991) and increase labour productivity (Ciccone and Hall 1996), leading to economic growth (Banister and Berechman 2000).

2.4.1. There is a positive association between transport infrastructure improvement and national welfare

Redding and Venables (2001) estimate the relationship between the potential access (determined by shipping costs) of a country's manufacturing goods to domestic and foreign markets and the GDP of the country. They find that potential market access explains up to 70 per cent of variations in countries' GDP per capita in 1996. Although the causative direction between the transport infrastructure (reflected by shipping costs) and GDP needs further research, their study supports the view that a country's development prospects are greatly affected by economic geography, of which transport costs are an important determinant.

Banerjee et al. (2012) investigate the effects of having access to transport infrastructure during the period 1986–2005 in China, when the country experienced rapid GDP growth. Using the (straight line) distance connecting historical cities as the measure of accessibility, they find that proximity to the transport network had a moderately positive causal effect on GDP per capita but could not identify any significant effects on household income or GDP per capita growth. They suggest mobility played an important role in determining the economic benefits of infrastructure in this case.

Bird and Straub (2014) explore the impact of the rapid expansion of the Brazilian road network from the 1960s to the 2000s. Using the 'historical natural experiment' constituted by the creation of the new capital city of Brasilia, they identify significant and positive impacts of transport infrastructure on GDP per capita. They attribute approximately 50 per cent of the growth in GDP per capita observed during the period to the road expansion.

Donaldson (2016) investigates the impact of India's vast railroad network on agricultural income per capita and economic welfare in India. Using archival district-level panel data from colonial India, a general equilibrium trade model is developed. The research finds that railroads decrease trade costs and interregional price gaps and increase interregional and international trade levels. It also finds that when the railroad network was extended to the average district, real agricultural income in that district rose by approximately 16 per cent. The caveat of the work is that it ignores the distributional effects of trade liberalisation that may arise from the increased trade flows generated by the railway network.

Donaldson and Hornbeck (2015) use a general equilibrium trade model to estimate the historical impacts of railroads on America's economy (with a focus on the aggregate impact on the agriculture sector). By constructing a network database of railroads and waterways, the researchers calculate the lowest-cost county-to-county freight routes and use this as a measure of counties' access to markets. From counterfactual simulations based on their estimated model parameters, they find that removing all railroads in 1890 would have decreased agricultural land values by 60 per cent and caused consumer welfare losses and population declines.

2.4.2. The evidence on relationships between transport infrastructure improvement, trade liberalisation and poverty alleviation shows a mixed picture

There is a strong underlying theoretical presumption that trade liberalisation will be poverty-alleviating in the long run and on average. The conventional trade theory is based on Ricardo's (1817) law of comparative advantage and the Heckscher–Ohlin model, which argues that, with perfect factor mobility, countries will gain by specialising in the production of goods which use their most abundant factor of production (Heckscher 1919; Ohlin 1933). For example, Michaels (2008) finds that the construction of the US interstate highway system boosted trade and led to greater demand for skilled labour in skill-abundant counties and greater demand for unskilled labour in skill-scarce counties. These findings are predicted by the Heckscher–Ohlin theorem. Gertler et al. (2016) study the local effects of road quality improvements in Indonesia. Using a nationwide panel dataset of road surface roughness as the measure of road quality, they find road improvements led to job creation in the manufacturing sector, which was also reflected in increased household incomes, consumption and land values. Moreover, they find evidence of a shift in occupations from agriculture to manufacturing, reducing the income gap between those in agriculture and manufacturing employment.

On the other hand, a rich empirical literature reports that the distributional consequences of international trade liberalisation are theoretically ambiguous (see Goldberg and Pavcnik 2007 for a review). Trade liberalisation necessarily implies distributional changes. These may reduce the well-being of some people (at least in the short term) and some of these may be poor. Recent trade models have also challenged the conventional theories, demonstrating that trade liberalisation can reduce the wages of unskilled labour even in a labour-abundant country, thereby widening the gap between the rich and the poor. For example, in India, Topalova (2010) finds that in the wake of international trade liberalisation, the poor and the geographically immobile became relatively worse off.

To summarise this chapter, efficient delivery of traded goods depends on both the transport infrastructure connectivity between the trading partners and the quality of their respective national transport infrastructures. Previous literature indicates that improving multimodal transport connectivity is important for trade expansion, industrialisation, regional integration and regional and national economic growth. However, the available evidence shows a mixed picture on where the economic benefits arising from improved transport infrastructure will accrue (spatially) or to whom.

3 Barriers to and facilitators of transport connectivity

In this chapter we identify key barriers to and facilitators of transport connectivity and trade more generally and how these relate to the BRI.[3] Many barriers could become facilitators, if resolved. We broadly categorise these barriers into two types: physical and soft. Physical barriers could include inadequate capacity in infrastructure and equipment or speed and cost of transporting goods. Soft barriers could include legal and regulatory barriers, project financing and security, (inhospitable) terrain or security surrounding trade routes. We also discuss the role of technology in facilitating supply-chain resilience and resource efficiency.

3.1. Missing transport links and other infrastructure can create bottlenecks

Currently, the quality of infrastructure across the BRI is uneven and discontinuous intermodal connections can create barriers that prevent the smooth functioning of railway traffic. These barriers stymie seamless passenger and freight transportation. A related challenge, as other connectivity projects such as the China–Pakistan Economic Corridor have shown, is that missing links between urban nodes can also require an enormous scale of investment (Ranjan 2015).

Conversely, identifying missing links and then working to promote and strengthen the infrastructure, complemented by continuous modernisation of technology in line with the latest technological trends, can facilitate the connectivity that is essential for stimulating growth.

3.2. The benefits of transporting goods through the BRI is dependent on speed and cost considerations

Transporting goods through the BRI could provide an appealing alternative – for instance, in comparison to air shipments – because of its relatively low cost; however, it will be necessary to address the challenge of slow speeds, and high transport costs could also be an issue.

In general, transport by rail is quicker than maritime shipments but slower than transporting goods via air. Accordingly, the transportation of goods by rail is more expensive than by sea but cheaper than by air (Duarte 2017). For instance, the time needed to travel the whole route

3 The findings of this section were generated through desk-based research, using academic and grey literature.

of the China Railway (CR) Express, which travels through China to Europe, is only 16 days, but transporting goods by sea is still two times cheaper (Du and Xianliang 2017). In contrast to air shipments, where customs and other types of red tape only occur at the beginning and end of the journey, transport on the ground can be interrupted at every border, which can lead to delays and increased costs due to various tariffs (Lehmacher et al. 2017). Speed is also hampered by insufficient infrastructure and equipment, which can create inefficiencies in the use of manpower and resources (Lehmacher et al. 2017).

Subsidies may be required in order to keep transport costs competitive. We see examples of subsidies on some of the freight line of the CR Express (Du and Xianliang 2017). A further example is the Hefei–Xinjiang–Europe line, which is subsidised by Chengdu, Chongqing, Wuhan and Zhengzhou. One expert from China Waterborne Transport Research Institute states that the subsidy from the local government is relatively low compared to the economic returns from the China–Europe freight train services (such as employment generation and tax). He also states that this situation will be improved with the high-speed railway connection between Asia and Europe.

To make rail transport a facilitator rather than a barrier, advancements that could increase its attractiveness could be considered, such as the instalment of state-of-the-art warehouse and inventory management systems or the creation of a single unified customs system (Lehmacher et al. 2017). Although there has been progress in reducing the costs of operating rail transport between China and Europe, such costs could be still further reduced through investments in IT infrastructure and other digital advances that could lower labour and other direct costs for firms interested in exploiting opportunities in shipments through the BRI (Lehmacher et al. 2017; Xie 2017).

3.3. Physical blockades such as inhospitable terrain and blocks at maritime entry points can create logistical obstacles

The topography of the terrain across the BRI, given the unusual scarcity of overland pathways and the physical geography of the Indian Ocean, can itself be a barrier. Geographical barriers such as mountain ranges, deserts and jungles that reach across South Asia sever transport links, preventing easy access between the Eurasian hinterland and the Indian Ocean (Brewster 2017). The Indian Ocean is also largely cut off on three sides with few maritime entry points, creating a strategic premium for 15th-century imperial strategists, such as Afonso de Albuquerque, who were able to exploit the oceanic chokepoint strategy to create an enclosed naval strategic space or *mare clausum* (Brewster 2017). Global trade chokepoints including maritime straits, ports and inland transport networks can cause significant disruptions in resource supplies such as energy or food (Bailey and Wellesley 2017).

3.4. Inconsistent legal and regulatory frameworks across borders can create delays and roadblocks

Legal and regulatory frameworks can be a barrier when variations in administrative processes at every checkpoint create impediments and inefficiencies for connectivity. Indeed, countries in most need of development may still be developing legal and regulatory systems, meaning that legal systems are incomplete or untested for foreign investments (Zhao 2016). For instance, complications in legal paperwork related to procuring land and obtaining permits led to the stalling of a US$1.1bn Chinese high-speed-rail project in Indonesia (Nikkei Asian Review 2016).

The interconnection, interoperability, legal liability and route capacity of the BRI will also pose important challenges, with differences in border crossing procedures and inefficient customs clearance procedures (Lehmacher et al. 2017) across state territories potentially leading to inconsistent standards, infrastructure gaps and missing transport links between nodes (Nazarko et al. 2016). These inconsistencies not only create delays, but also open up the system to manipulation (Lehmacher et al. 2017).

Alternatively, legal and regulatory frameworks can also become facilitators to trade if administrative processes and procedures are simplified and made more consistent along the BRI corridors, and if information sharing along the route is optimised (Transport Planning and Research Institute 2016). A legal and constitutional structure that is tailored and adapted to the novel and complex challenges arising from such a large-scale and cross-border project is crucial to realising the BRI's potential.

3.5. Geographical overlaps in connectivity initiatives of neighbouring countries can generate conflict or opportunities for collaboration

Other parallel connectivity projects cover some of the same geographical areas as the BRI, for example in the EU, Russia's Eurasian Economic Union (EEU) and the South Asian Association for Regional Cooperation (SAARC). Although China is outside the SAARC for example, China's growing influence in the South Asian region is seen through a geostrategic lens by India, which could have negative implications if China and India perceive each other's connectivity projects in competitive or adversarial terms (Das 2017).

One mitigating measure that may help avoid conflict and alleviate tensions is to pursue positive engagement and convergence and synergies between initiatives, thus creating opportunities for collaboration. For example, the Bangladesh–China–India–Myanmar initiative demonstrates opportunities for the merging of regional initiatives with the BRI (Das 2017) that could lead to win-win collaborations.

3.6. The security environment across the BRI will be crucial to protect investments

There is a range of possible security threats that could interrupt normal operations of transport across the BRI, including terrorism, piracy, maritime conflict, organised crime networks and grassroots political pressure. Investments will need to be secured in the context of several of the countries most in need of development along the BRI corridors, which are also sites of violent conflicts, ethnic clashes, insurgency, separatism and radicalism (Mishra 2016). To name a few, Pakistan, Afghanistan and southern areas in Thailand all have unstable security environments (Mishra 2016). Increasing tensions in the Pacific could also potentially lead to maritime blockades that cause disruptions for the BRI, for instance in the event that the United States imposes a naval blockade due to maritime conflict in East Asia (Rolland 2015). This means that China could find itself with a growing stake in the conflicts of its surrounding neighbours in the BRI. Another security threat could be popular dissent against Chinese infrastructure development projects. Such threats have terminated projects in the past, demonstrating the potential risks that popular opinion could pose. For instance, the Chinese-backed Myitsone Dam project in Myanmar stalled due to protests from the local population (Ives 2017).

Conversely, infrastructure development across these areas is also envisaged by the Chinese government as a stabilising measure. For example, China's Xinjiang region is affected by radicalisation and conflict, and the government is seeking to utilise the launch of railways connecting the region to neighbouring countries in Central Asia, stretching towards the Middle East and Europe, to introduce political stability through economic development (Rolland 2015). Consultative processes with participating countries across the BRI could also clear misunderstandings and ensure more inclusive regional cooperation (Das 2017).

3.7. Information technology can facilitate improved supply-chain resilience and introduce more resource efficiency

The tracking and visibility of goods being transported and the generation of real-time tracking information could also be consolidated (Lehmacher et al. 2017) and advanced in order to protect the security of the BRI routes. For instance, technological advances such as low-cost satellites that could be accessed through mobile phones and other handheld devices, or distributed ledger technology (DLT), can help with tracking of goods (Lehmacher et al. 2017). DLT uses block-chain technology to generate records of transactions across networks (Lehmacher et al. 2017).

Additionally, automation can aid in reducing labour and other direct costs. For example, labour-intensive activities such as loading and unloading, arranging paperwork and optimising capacity could be automated, and warehouse automation can reduce delays and associated costs (Lehmacher et al. 2017).

Digital technology can also help create platforms for collaboration, which can allow regional logistics providers to share assets and information outside their coverage area to leverage partners' infrastructure. Advancements in the digital economy can, in turn, also provide new employment opportunities and attract more foreign direct investment (Lehmacher et al. 2017).

3.8. Summary

Ultimately, the BRI holds great promise to boost trade and economic growth, but several barriers will need to be converted into facilitators. Legal and regulatory inconsistencies need to be addressed and streamlined across the BRI's overland and maritime corridors in order to reduce costs, increase the speed of transportation and make the BRI more attractive for investors. Positive engagement with countries across the BRI could turn competitors into partners, thus generating synergies between objectives and creating opportunities to leverage each other's resources to ensure the BRI delivers sustained economic, social and environmental (Dossani 2016) benefits across generations. Transport infrastructure requires considerable investment; however, several countries across the BRI score highly in terms of investment risk (The Economist Intelligence Unit 2016) and delays and political and security risks can make the BRI less attractive for investors. Creating clear security arrangements and mechanisms to ensure the safety and security of goods travelling across the BRI can also help protect investments. Finally, advancements in information and digital technology and automation can help improve multimodal transport connectivity by creating digital and information-sharing networks, collaborative platforms and opportunities to improve efficiency and supply-chain resilience.

4 Measuring multimodal transport connectivity and infrastructure

Above we have identified barriers and facilitators relating to multimodal transport infrastructure and connectivity in the BRI region. In this and the following sections, we aim to quantify the impact of removing physical barriers to trade. To model the link between trade flows and transport connectivity, we first define a series of transport performance and connectivity measures for air, sea, rail and road modes and describe how these measures vary across the study area.

4.1. Defining transport performance measures

As discussed in the literature review (section 2), the time required for goods to reach their respective markets in international trade and delivery reliability depends as much on the infrastructure behind borders as on the transport infrastructure and services between the trading partners. Therefore, we aim to test the impacts of transport infrastructure both within and between the trading nations.

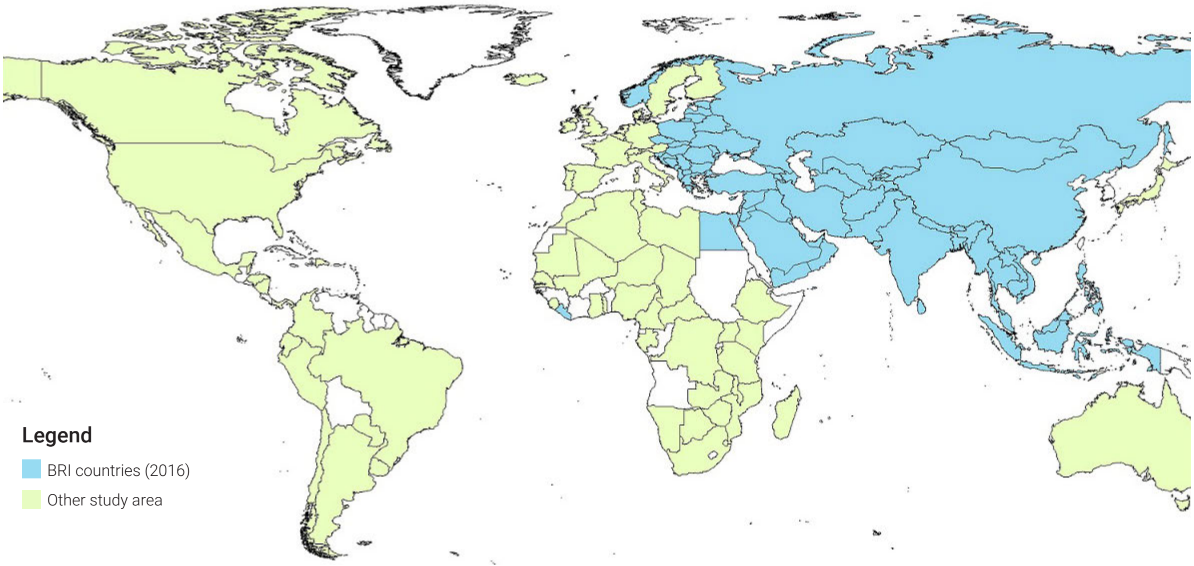
The first stage is to select and develop transport performance measures. Ideally, such indices would combine data on the quantity and quality of transport facilities for each mode. We measured the quantity and quality of the infrastructure across modes using airport density, road density, rail density and maritime performance indices and the World Bank's logistics performance index (LPI)[4] (using a similar approach to Nordas and Piermartini [2004] and Shepherd et al. [2011]). The advantage of these indices is that they are broadly available for most of the countries of interest. They also allow us to disentangle and explicitly estimate the role of different transport modes on trade flows.

Below, we present a descriptive analysis of the transport infrastructure for the study area shown in Figure 2. The study area comprises 65 BRI countries (up to 2016),[5] 28 EU member states and a few other countries that are directly or indirectly affected by the BRI. We further split the BRI into six subregions: East Asia (2 countries), South-East Asia (11 countries), Central Asia (5 countries), Middle East and North Africa (15 countries), South Asia (14 countries) and Europe and North-West Asia (18 countries). The detailed country list can be found in Appendix A.

4 The LPI is a comprehensive measure of the efficiency of international chains (World Bank 2016).

5 Due to data availability, we only included 46 countries within the BRI and in total 108 countries in the modelling analysis presented in the next section.

Figure 2 Map of study area



4.1.1. Aviation

Airport density (the total number of airports divided by the land area) is used to represent the quantity of aviation infrastructure in each country. The total number of airports is sourced from the CIA World Factbook,[6] which includes the number of paved and unpaved airports. Most of the transport information from the CIA World Factbook was collected up to 2013.[7]

Table 1 provides a descriptive analysis which includes the minimum, maximum and average airport densities across the regions and countries. There is a wide variation both across countries and within the BRI region. We also observe a large gap between countries within the same BRI subregion. For example, in South-East Asia, Cambodia has the lowest airport density at 0.09 per 1,000 km^2, while Singapore has the highest airport density at 13.10 per 1,000 km^2, 145 times of that of Cambodia. Figure 3 shows the airport density across the study area. We find a relatively low airport density in the BRI region compared to the EU or America.

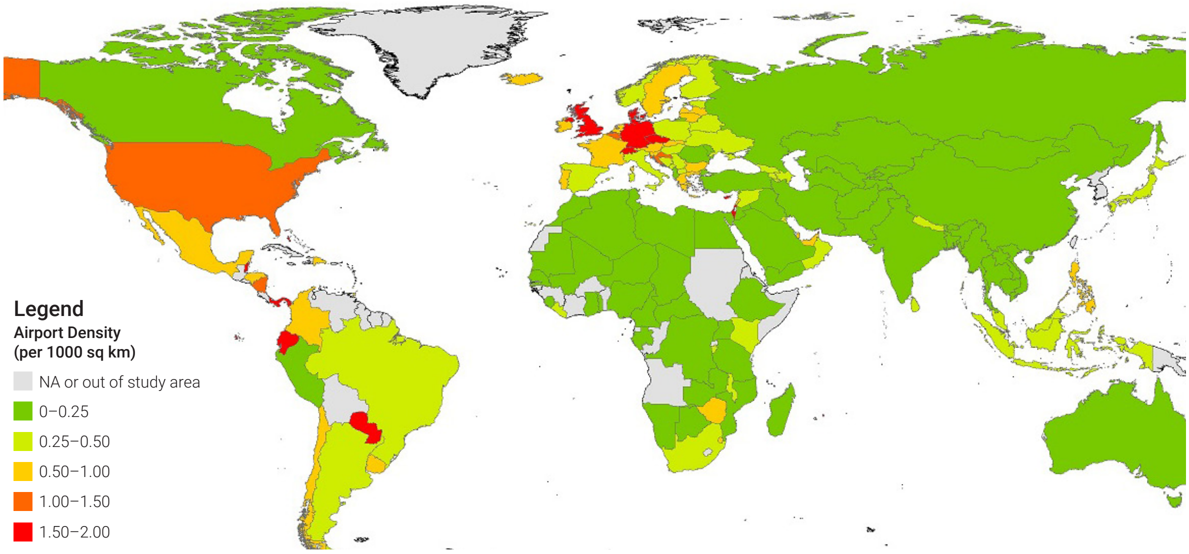
6 The CIA World Factbook provides information on history, people, government, economy, geography, transport, military and transnational issues for 267 world entities. See Central Intelligence Agency (2018).

7 This was by the time the research was undertaken

Table 1 Descriptive analysis of airport density (per 1,000 km²)

	Region	Minimum		Maximum		Average
BRI	East Asia	Mongolia	0.03	China	0.05	0.04
	South-East Asia	Cambodia	0.09	Singapore	13.1	1.45
	Central Asia	Kazakhstan	0.04	Tajikistan	0.17	0.11
	Middle East and North Africa	Egypt	0.08	Bahrain	5.26	0.83
	South Asia	Afghanistan	0.07	Maldives	30.2	3.93
	Europe and North-West Asia	Russian Federation	0.07	Czech Republic	1.66	0.51
EU		Romania	0.2	Malta	3.16	0.94
Other countries		Mali	0.02	Seychelles	30.77	1.23
All study areas		Mali	0.02	Seychelles	30.77	1.15

Figure 3 Airport density (per 1,000 km²)



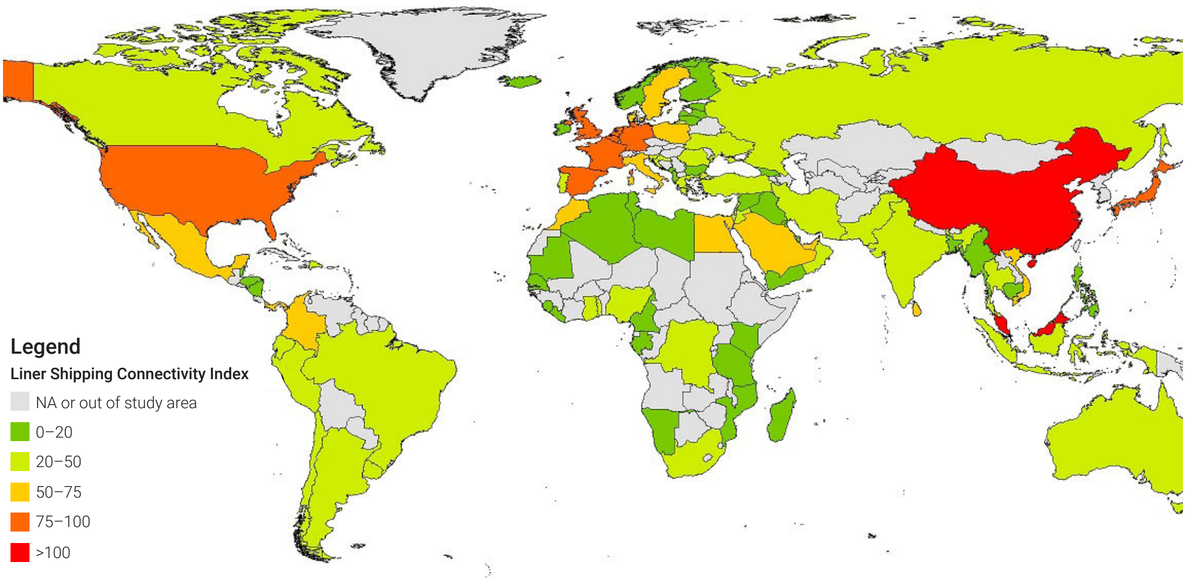
Source: CIA World Factbook (2013)

4.1.2. Maritime transport

UNCTAD's Liner Shipping Connectivity Index (LSCI) serves as a readily available reference to measure maritime quality. It uses principal components analysis to combine a variety of liner shipping indicators into a single, broad-based index (UNCTAD 2009). The LSCI takes account of the following factors: number of ships, the ships' container-carrying capacity, maximum vessel size, number of services and number of companies deploying container ships to and from a country's ports. The five factors cover both the quantity and quality of maritime transport.

Figure 4 shows the LSCI for each country. Apart from China and a few countries in South Asia, most of the BRI region countries have relatively low LSCI scores compared to EU and other major economies.

Figure 4 LSCI by country



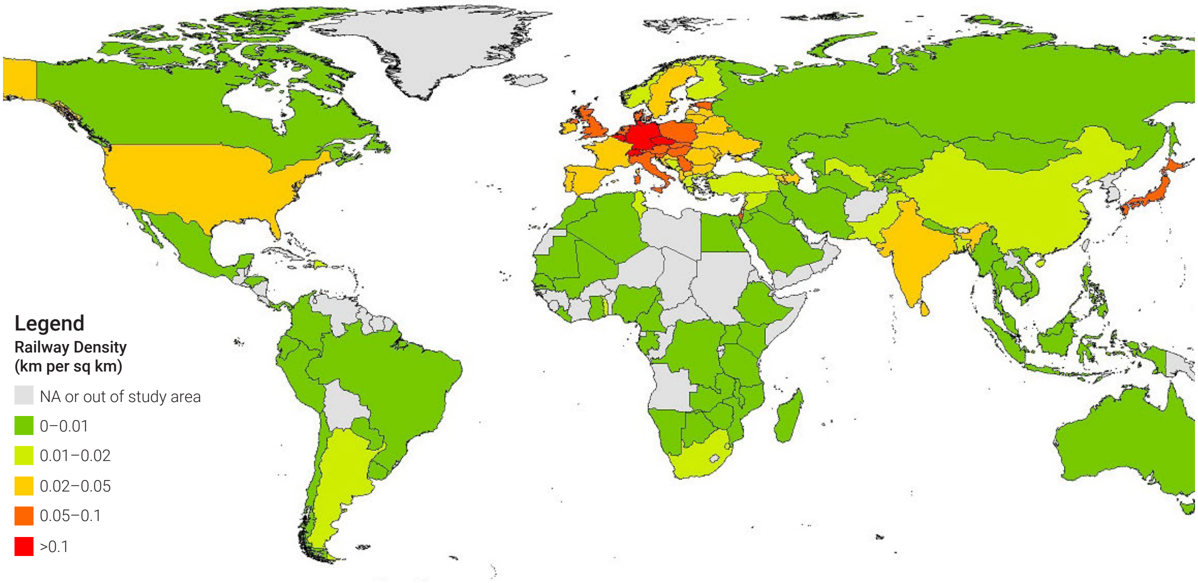
Source: UNCTAD LSCI (2013)

4.1.3. Railway

Strong land transport is an important element for intranational trade (transport of goods within the country); it also fosters international trade by supporting the shipping of goods shipping between factories, ports and warehouses. Railway infrastructure is measured by railway density (total railway length/land area). This is the same approach used in Limão and Venables (2001) and Shepherd et al. (2011). The railway network length data is sourced from the CIA World Factbook (2013). The data includes both passenger and freight transport.

Figure 5 shows railway density by country. As with the maritime transport index, we generally find that the countries in the BRI region have a low rail density compared to EU countries and some of the other major world economies, especially in the South and West Asia regions. A few countries (such as Bhutan, Brunei Darussalam, Laos and Singapore) do not have railway infrastructure due to geographical or historical circumstances. A few countries (such as Cambodia and Nepal) have local railway transport networks but intercountry rail connections are relatively poor.

Figure 5 Railway density by country (per km²)



Source: CIA World Factbook (2013)

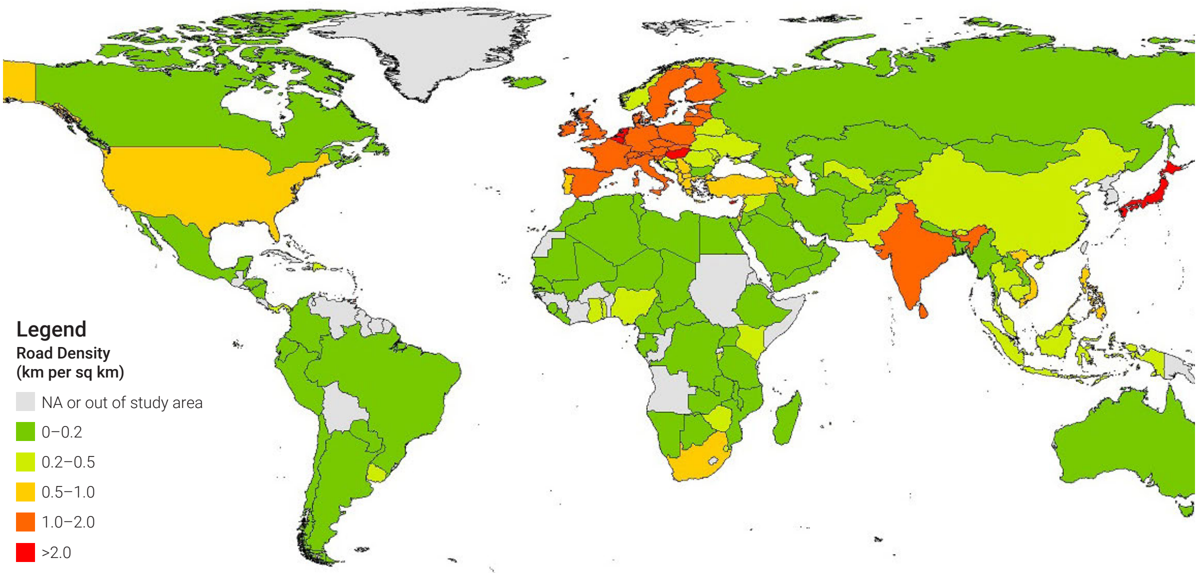
Table 2 Descriptive analysis of railway density (per km²)

	Region	Minimum		Maximum		Average
BRI	East Asia	Mongolia	0.00	China	0.01	0.01
	South-East Asia	Brunei Darussalam	0.00	Vietnam	0.01	0.00
	Central Asia	Kyrgyzstan	0.00	Uzbekistan	0.01	0.01
	Middle East and North Africa	United Arab Emirates	0.00	Israel	0.06	0.01
	South Asia	Bhutan	0.00	India	0.02	0.01
	Europe and North-West Asia	Russian Federation	0.01	Czech Republic	0.12	0.04
EU		Bahamas	0.00	Germany	0.12	0.06
Other countries		Bahamas	0.00	Switzerland	0.14	0.01
All study areas		Bahamas	0.00	Switzerland	0.14	0.02

4.1.4. Roadway

Another important element of the land transport network is roadway density (roadway length/ country land area) and this is used to measure countries' roadway infrastructure. The distribution of roadway density across countries is shown in Figure 6. The roadway statistics include both paved and unpaved roads. India has a higher road density than the United States and China. However, India's roads are a mix of modern highways and narrow unpaved roads (over 38 per cent as of March 2015) which are being improved (*Indian Road Network* 2018).

Figure 6 Roadway density (per km²)



Source: CIA World Factbook (2013)

Table 3 Descriptive analysis of roadway density (per km²)

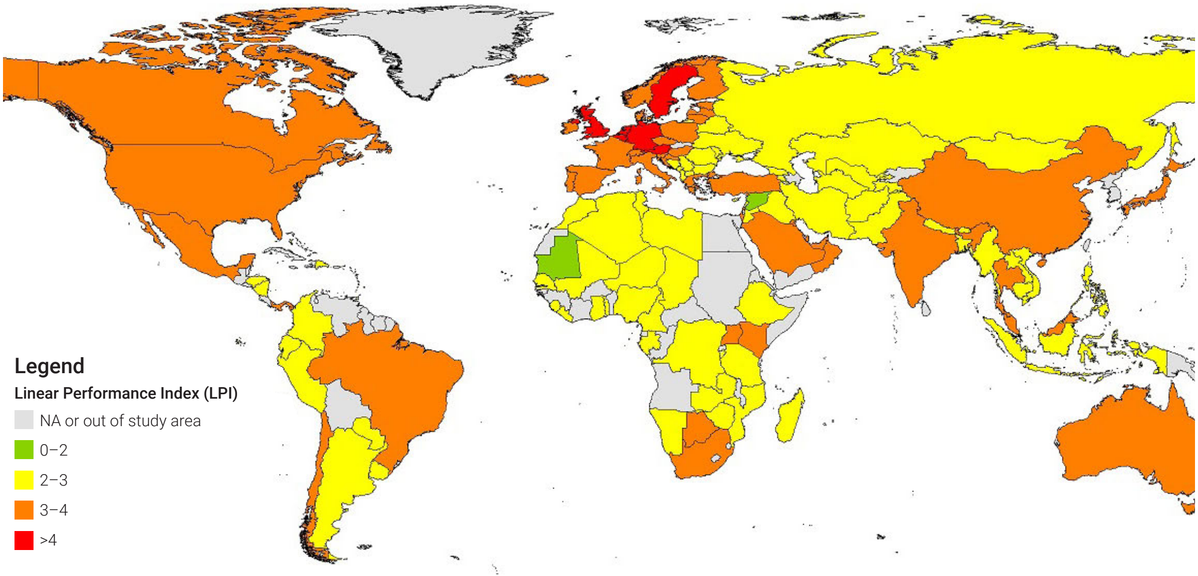
	Region	Minimum		Maximum		Average
BRI	East Asia	Mongolia	0.03	China	0.49	0.26
	South-East Asia	Myanmar	0.05	Singapore	4.99	0.81
	Central Asia	Kazakhstan	0.04	Uzbekistan	0.2	0.15
	Middle East and North Africa	United Arab Emirates	0.05	Bahrain	5.42	0.68
	South Asia	Afghanistan	0.06	Sri Lanka	1.77	0.59
	Europe and North-West Asia	Russian Federation	0.08	Hungary	2.27	0.79
EU		Bulgaria	0.18	Malta	9.8	1.9
Other countries		Mauritania	0.01	Japan	3.34	0.34
All study areas		Mauritania	0.01	Malta	9.8	0.73

4.1.5. Overall logistics performance

Finally, we also incorporate the LPI, sourced from World Bank data (2016). Drawn from survey responses from logistics professionals around the world, the LPI is calculated based on private-sector perceptions of supply-chain performance and bottlenecks. The index is composed using principal components analysis and covers the following aspects: 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 timeline of delivery.

Within the BRI region, the gap in logistics performance is wide, with Syria achieving the lowest score at 1.59 and Singapore the highest at 4.23. Most countries (especially in North Asia and Europe, and some countries in South/West Asia) achieve relatively low scores (2–3 or below 2). However, a few countries (such as China, India, Malaysia, Thailand and some countries in southern or East Africa) showed scores close to those of the other economies. There are several reasons for the wide gaps between countries (Arvis et al. 2016). First, there is a perceived improvement in trade-supporting infrastructure in low- and middle-income countries such as China and Malaysia. Second, international supply chains may be normally organised across groups of regional trading countries; thus, for example, the improvement of logistics performance in southern Africa or East Africa is partly due to the significant improvement in trade corridor efficiency. However, due to lack of integration, political unrest and security challenges, North African and Middle Eastern developing countries are doing comparatively worse. Similarly, in South Asia, lack of integration means that the good logistics performance of India does not improve that of all its neighbours. Meanwhile, East Asian economies perform generally well across LPI domains.

Figure 7 LPI by country



Source: World Bank LPI (2013)

We summarise and compare the weighted average (by land area) transport indices for three regions in the study area: the BRI, the EU and other countries, as shown in Table 4. As the LSCI and LPI are composite indices, we only included airports, railways and roadways in the comparison. On average, the quality and quantity of transport infrastructure in the BRI region are much lower compared to the EU. In terms of airport and railway density, the density in the EU is over five times that of the BRI region. For roadways, the network density in the EU is over ten per cent higher than in the BRI region.

Table 4 Descriptive analysis of the transport infrastructure for the EU, the BRI region and other countries (weighted by land area 2013)

	Airport density (per 1,000 km^2)	Rail density (per km^2)	Road density (per km^2)
EU	0.732	0.055	1.451
BRI region	0.125	0.010	1.315
Other countries	0.435	0.009	1.227

Source: CIA World Factbook (2013)

4.2. Measuring connectivity of multimodal transport between countries

In the conventional trade model (which will be discussed in section 5), the distance between trading partners is used as a proxy for the transport cost faced by the exporter to ship goods to the importer. Ideally, we should use journey time by modes, journey cost and service quality information to reflect an overall composite measure of connectivity. Indeed, journey time is important for traders to understand the relative competitiveness of different transport modes and make choices about what mode of travel to use for shipping their goods. Many traders will make a trade-off between the monetary transport cost and journey time. For instance, shipping commodities from China to Germany would take up to two days via air transport (with the highest monetary transport cost) and 14 days via railway transport but over a month via maritime transport (with the lowest transport monetary cost).

In the economic literature, Hummels (2001a) used times in transit for different transport modes to quantify the time barrier to trade. However, detailed data on journey times using different transport modes is only available for a small number of countries (such as the United States and some EU member states). Hummels argued that the time in transit had a strong correlation with the quality of ports, port services and customs procedures. In the present study, we try to use transport infrastructure and service quality indices to represent time in transit. While ideally we would capture the impact of transit time on trade, our ability to analyse the impact of journey time is limited by the availability of data in this wide study area.

Some other economic studies use the cif/fob ratio to represent the transport cost. We are not able to use such measures due to the limited data availability in the wide regions of interest to this study. In addition, Nordas and Piermartini (2004) state that the cif/fob ratio is a very imprecise measure of transport cost as it varies with the commodity composition of trade flow. In addition, much cif/fob data is imputed from other sources.

In the study by Baniya et al. (2017), georeferenced data and geographical information system (GIS) analysis are used to compute the reduction in bilateral trade time induced by the proposed (new or improved) railway infrastructure, estimating that the new connections in the Eurasian region would reduce travel times by rail by 26 per cent on average.

Since data on direct transport costs is either unavailable or of poor quality, information on bilateral distance and geography and the transport infrastructure indices are used as proxies in the quantitative modelling. To measure the connectivity of multimodal transport between countries, we used the distance between the bilateral country pairs in the study area using different modes (using a similar approach to Herrero and Xu [2016]). The variation of the distances may capture to some extent the difference in cost.

Rail distances are calculated from Rome2rio[8] as the distance between the capital cities of the two trading countries. Note that for quite a few country pairs, there are no direct train services (journeys may require transfer via roadway or ferry). For some country pairs, there are no train services (for instance from Asia to America). Therefore, we also include an indicator variable 'No rail connection' to reflect that there is no rail service between trading partners. We find over two-thirds of the country pairs in the study area are not linked by direct railway services.

Air distances between the two capital cities are also collected from Rome2rio. We compared these with CEPII[9] geodistance data and found that the two measures are fairly consistent. Some bilateral distance examples are provided in Appendix B.

Maritime distance data is obtained from the CERDI (FERDI 2016) sea distance database. The CERDI database contains bilateral maritime distances between 227 countries and territories. The length of the shortest existing sea route between two ports is computed, including the access distance to the sea. For landlocked countries, this is calculated as the distance from the nearest (foreign) port to the capital city.

Table 5 presents a descriptive analysis of the transport connectivity by region. The railway distance is not presented due to the poor rail connectivity in the study area. As the CEPII and the air distance are close to crow-fly distances between countries, we conclude that on average, BRI regions have slightly longer travel distances between trading partners compared to EU countries, but shorter distances between trading partners compared to other economies selected in the study. In terms of the maritime distance, again, the BRI region sits in between the EU and other countries.

Table 5 Descriptive analysis of transport connectivity (average)

	Distance (CEPII, km)	Air distance (km)	Maritime distance (km)
EU	5,147	5,121	7,999
BRI	6,068	6,086	9,030
Other countries	8,170	8,224	10,346

8 Rome2rio is a comprehensive multimodal transport search engine launched in April 2011 (Rome2rio n.d.).

9 The CEPII geodistance database provides bilateral distances measured using city-level data to account for the geographical distribution of population inside each nation. The CEPII database is widely used in the trade gravity model to provide transport costs (CEPII n.d.).

4.3. Summary

Based on a literature review drawing on previous empirical evidence, we constructed a series of indices to measure transport infrastructure (quality and performance indices) and connectivity relating to the key modes of interest (aviation, railway, roadway, maritime and logistics performance). The descriptive analysis shows there is large variation in the quantity and quality of infrastructure across countries within the BRI and in the wider study area.

In the next section, we will estimate the linkage between these transport indices and international trade through econometric models and counterfactual simulation tests.

5 Measuring the impact of the BRI on trade

5.1. Brief introduction

The second stage of the quantitative analysis is to develop an empirical model to quantify the impact of removing physical barriers – more specifically, improving transport infrastructure across the BRI regions – on international bilateral trade. As discussed in the previous sections, the transport infrastructure and connectivity are measured using a series of broad-based indicators. In this section, we incorporate these measurements into a gravity model to quantify their impacts on trade. First, we provide a brief review on the theoretical background of the gravity model. Second, we present the resulting empirical models with interpretation of the model findings. Third, we predict the potential trade effect for the BRI region of the improvement in transport infrastructure and connectivity.

5.2. Theoretical background of the gravity model

The gravity model has been widely used to analyse trade patterns and trade impacts (see Anderson [2011] and Shepherd [2012] for an overview). The model originates from Newton's Law of Universal Gravitation, i.e. that any particle in the universe attracts any other particle due to a force that is directly proportional to the product of the particles' masses and inversely proportional to the square of the distance between them. Just as particles are mutually attracted in proportion to their sizes and proximity, it is hypothesised that in international trade countries trade in proportion to their market size (e.g. GDP) and proximity (distance between the countries). The proximity (distance) represents the cost (trade cost) associated with the trade (see Samuelson 1939).

Anderson (1979) was the first to establish a theoretical economic foundation for the gravity model. In the model, consumers have preferences regarding a variety of differentiated goods (Constant Elasticity of Substitution [CES[10]]). The goods are differentiated by origin. The trade costs in the model (so-called 'iceberg' costs) are proportional to the shipped goods and reflect

10 Armington (1969) introduced the assumption that final products traded internationally are differentiated on the basis of the location of production. In essence, he assumes that in any country every industry produces only one product, which is distinct from the product of the same industry in any other country.

the assumption that only a fraction of the goods shipped will arrive at the destination. Literature reveals that a gravity-type model can be derived for any traditional trade model. Recent studies have focused on an exploration of the economic foundations underlying gravity equations (Anderson and van Wincoop 2003; Arkolakis et al. 2012; Eaton and Kortum 2002).

The seminal work in this area is a model by Anderson and van Wincoop (2003), which assumes that bilateral trade flows are determined by relative trade costs rather than solely by absolute trade costs.

Their gravity equation takes the following form:

$$X_{ij} = \frac{Y_i Y_j}{Y} \left(\frac{t_{ij}}{K_i P_j}\right)^{(1-\sigma)} \quad (1)$$

$$K_i = \sum_{j=1}^{N} \left(\frac{t_{ij}}{P_j}\right)^{(1-\sigma)} \frac{Y_j}{Y} \quad (2)$$

$$P_j = \sum_{i=1}^{N} \left(\frac{t_{ij}}{K_i}\right)^{(1-\sigma)} \frac{Y_i}{Y} \quad (3)$$

Where X_{ij} represents exports from country i to country j, Y_i is the GDP of country i, Y_j is the GDP of country j, Y is the world's GDP, σ is the elasticity of substitution between product varieties and t_{ij} is the bilateral trade cost of sending products from country i to country j. K_i and P_j represent outward and inward multilateral resistance (multilateral trade resistance [MTR]), which capture the fact that export from country i to country j is determined by trade costs across all possible export and import markets.

The MTR represents the barriers (relative trade cost) which country i and country j face in the trade with all their trading partners (including internal trade). For instance, trade between Germany and China depends on the costs for each of them in trading with all other countries, not only the cost between these two countries. A reduction in a bilateral trade cost between China and a third country such as Belgium would reduce China's MTR. Even though the bilateral trade cost between China and Germany remains unchanged, the fall in China's MTR (due to the reduction of trade cost between China and Belgium) would lead to a diversion of trade away from China–Germany to trade between China and Belgium (spillover effect). Failure to account for the multilateral resistance effects would lead to upward bias in the estimates of gains from improvements.

Given its multiplicative nature, the gravity equation outlined in (1) can be transformed by taking the logarithms to a log-linear form illustrated as follows:

$$lnX_{ij} = lnY_i + lnY_j - lnY + (1 - \sigma)(lnt_{ij} - lnK_i - lnP_j) \quad (4)$$

Due to the lack of a direct measure of trade cost, t_{ij} is usually specified empirically as a function of observable variables that are seen as directly correlated to trade cost. In the literature, a log-linear specification is often applied as follows (Mayer and Zignago 2011):

$$ln(t_{ij}) = \beta_1 \ln(distance_{ij}) + \beta_2(contig_{ij}) + \beta_3(comlang_{ij}) + \beta_4(colony_{ij}) \quad (5)$$

Where *distance* is the geographical distance between countries i and j, *contig* is a categorical variable equal to one if countries share a common land border, *comlang* is equal to one if country pairs share the same language and *colony* is equal to one if countries i and j were in a colonial relationship. These factors reflect the hypotheses that transport costs increase with distance and are lower for neighbouring countries. Indicators for common language or colonial history are related to information costs with regard to trade, where search costs are presumably lower for trade between countries whose culture and business practices are known to each other. Empirically, all these factors have been found to be significant drivers of bilateral trade.

5.3. Empirical methodology and data

We estimate the parameters of a gravity model that captures the trade patterns of the countries within the BRI region, EU member states and the other countries selected in the study. In total 108 countries are included in the model (46 BRI countries/regions, 27 EU countries[11] and 56 other countries). Some countries are excluded due to a lack of data. The detailed country list is presented in Appendix A.

5.3.1. Baseline gravity model

To capture the multilateral resistance effect, Anderson and van Wincoop (2003) and Head and Mayer (2000) proposed a structural specification of the model. However, the non-linear calculation involved sometimes has difficulty in convergence and may be sensitive to the initial parameter choice. Baier and Bergstrand (2009) suggested a simple yet effective approach which takes a linear approximation (by a first-order Tylor series expansion) of the multilateral resistance terms to avoid the complexity involved in the non-linear procedure in the traditional structural gravity model. Following this approach, the multilateral resistance terms are written as:

$$\ln K_i = [\textstyle\sum_{j=1}^{N} w_j \ln(t_{ij}) - \frac{1}{2} \sum_{k=1}^{N} \sum_{m=1}^{N} w_k w_m \ln(t_{km})] \qquad (7)$$

$$\ln P_i = [\textstyle\sum_{i=1}^{N} w_i \ln(t_{ij}) - \frac{1}{2} \sum_{k=1}^{N} \sum_{m=1}^{N} w_k w_m \ln(t_{km})] \qquad (8)$$

Substituting equations (6), (7) and (8) into equation (3), we then get:

$$lnX_{ij} = lnY_i + lnY_j - lnY + (1 - \sigma)(lnt_{ij}^{*}) \qquad (9)$$

$$\ln t_{ij}' = lnt_{ij} - \textstyle\sum_{j=1}^{N} w_j\, ln(t_{ij}) - \sum_{i=1}^{N} w_i \ln(t_{ij}) - \sum_{k=1}^{N} \sum_{m=1}^{N} w_k w_m \ln(t_{km}) \qquad (10)$$

Where w represents the GDP share of the country and k and m refer to the country pairs in the study.

11 There is overlap between the BRI region and the EU; see the detailed list presented in Appendix A.

To account for the MTR, each transport index is specified using equation (10). For instance, the roadway distance variable is incorporated in the model as:

$$\ln(roaddist'_{ij}) = ln(roaddist_{ij}) - \sum_{j=1}^{N} w_j ln(roaddist_{ij}) - \sum_{i=1}^{N} w_i \ln(roaddist_{ij}) - \sum_{k=1}^{N}\sum_{m=1}^{N} w_k w_m \ln(roaddist_{km}) \quad (11)$$

In this way, the roadway distance change between one bilateral trading pair will have an impact on all the other exporters and importers through the MTR terms. The MTR is also determined by the relative size of the exporters/importers.

Our research hypothesis is that transport infrastructure and multimodal connectivity between countries impact on the trade cost t_{ij}, and thus also on the bilateral trade. The specification of trade cost is therefore estimated as follows:

$$\begin{aligned} ln(t_{ij}') = \; & \beta_{1rail}\ln(raildist_{ij}') + \beta_{1Norail}(WithNoRail') \\ & + \beta_{1maritime}\ln(maridist_{ij}') + \beta_{1air}\ln(airdist_{ij}') \\ & + \beta_2\ln(rail\_density_{ij}') + \beta_3\ln(road\_density_{ij}') + \beta_4\ln(airportden_{ij}') \\ & + \beta_5\ln(logistic_{ij}') + \beta_6\ln(tarrif_{ij}') \\ & + \beta_7(contig_{ij}) + \beta_8(comlang_{ij}) + \beta_9(colony_{ij}) \qquad (12) \end{aligned}$$

We use equation (11) to specify the transport infrastructure (rail density, road density and airport density), transport connectivity (rail distance with the 'No rail connection' term, maritime distance and air distance), logistics performance indices (LSCI and LPI) and the 'Tariff' term. The data source will be discussed in the section 5.3.2. Then, using the parameters estimated from the gravity model, we can predict the impact of a change in one or more of these variables on the bilateral trade (counterfactual analysis). This will be discussed in detail below.

With regard to the geographical variables (*contig, comlang and colony*), these are not likely to change; therefore, we keep them as simple terms as above in the gravity model.

5.3.2. Data sources

The gravity model presented here uses standard data sources, in addition to the multimodal transport infrastructure and connectivity indices discussed above and in section 4. Table 6 provides a full summary of the data sources. The bilateral trade data is from COMTRADE, which is the most common source of data on disaggregated trade by commodity. Data from 2013 are used in the study. Trade values are in US$ converted from national currencies. Data is also available through the United Nations website (UN COMTRADE 2018). GDP data is from the World Bank Development Indicator database (World Bank 2018). The bilateral tariff data is from the UNCTAD TRAINS database. Tariff rates are effective bilateral rates that take account of regional and preferential trade agreements. They are averaged by applying trade weights. For a few countries, the tariff data was not available for 2013. In these cases, we imputed values from 2014.

The sources of transport infrastructure and connectivity measurements were discussed in the previous chapter. The model also includes standard gravity model controls such as colonial history (*colony*), common border (*contig*) and common language (*comlang*), taken from the CEPII GeoDist database (Mayer and Zignago 2011). Note that there are two common language constants: the first reflects whether two countries share a common official language, and the second whether a language is spoken by at least 9 per cent of the population in both countries. For this analysis we only use the first indicator.

Table 6 Data sources for the gravity model (2013)[12]

	Variable	Description	Source
Economic indices	Exports	Total exports from country i to country j	UN COMTRADE
	GDP	Nominal GDP in US$	World Development Indicators
	Tariff rate	Effectively applied tariff, trade weighted average	TRAINS via UNCTAD
Transport infrastructure indicators	Airports	The number of primary and secondary airports	CIA World Factbook
	Rail density	Road network length/land area of the country	CIA World Factbook
	Rail density	Rail network length/land area of the country	CIA World Factbook
	Logistics performance	LPI score on the competence and quality of logistics services	World Bank
	Maritime transport	Linear Shipping Index (LSI) score on the competence and quality of logistics services	UNCTAD
Transport connectivity	Air transport distance	The bilateral air distance between the capitals of country pairs	Rome2rio
	Rail and road distance	The bilateral rail and road distance between the capitals of the country pair	Rome2rio and Google Maps
	Without rail connection	The indicator variable that equals unity if there is no direct rail connection between the capitals of country pairs	Rome2rio and Google Maps
	Maritime distance	The maritime distance between the capitals of the country pair	CERDI sea distance
Distance	Distance	Bilateral distance between the capitals of country pairs – not differentiated by mode	CEPII GeoDist database
Other controls	Colony	Dummy variable equal to unity if one economy was once a colony of the other	CEPII GeoDist database
	Common border	Dummy variable equal to unity for economies that share a common land border	CEPII GeoDist database
	Common language	Dummy variable equal to unity for economies that share a language spoken by more than 9 per cent of the population	CEPII GeoDist database

12 We use the data from 2013 in the gravity model as most of the transport infrastructure indices data is from 2013.

5.3.3. Descriptive analysis

Table 7 provides a descriptive analysis of the economic data for the BRI, EU and other countries. We observe a great extent of variation of GPD and exports within each region. For instance, in the BRI region, the Maldives has the lowest GDP in 2013 at US$2.8 billion while China has the highest at US$9.61 trillion.

Table 7 Economic data descriptive analysis by region

GDP (US$ trillion)	Max		Min		Average
BRI	9.61	CHN	0.003	MDV	0.68
EU	3.75	DEU	0.01	MLT	0.65
Other countries	16.69	USA	0.00	SYC	0.81
Trade values (US$ trillion)					
BRI	0.37	CHN			
EU	0.14	NLD			
Other countries	0.30	USA			
Tariff (US$)					
BRI	579.74	EGY			4.97
EU	18.44	AUT			3.28
Other countries	1,358.42	ISL			6.16

Note: Data sources are listed above in Table 6

The relationships between exports and the transport indices are plotted and included in Appendix C. We observe positive correlation, especially for the LPI.

5.3.4. Model limitations

A major limitation of gravity models is that they focus on trade volumes and do not represent the indirect linkages between the various elements in the economies for different sectors at a more disaggregated level.

Unlike computable general equilibrium (CGE) models, which provide explicit links between changing production and consumption patterns and changes in trade, the gravity model can only identify the static effects of transport infrastructure on bilateral trade, keeping all other factors constant (i.e. it can only generate the first-order effect on trade). It also does not explicitly take into account the balance between supply and demand for goods, services and production in the longer term. Further, it does not reflect how firms and households respond to changes in transport costs. The only metric we directly observe in applying the gravity model outlined in equation (9) is changes in patterns of bilateral trade volumes as a result of transport connectivity, tariffs and other trade characteristics, such as the presence of a common border, common language and historical relationships. In what follows, it is also important to emphasise that the results from the empirical model show associations between transport cost and bilateral trade rather than causal relationships.

Furthermore, the empirical model might not capture all the variables that influence trade flows and trade barriers. We mitigate this issue by controlling for as many control variables as the data allow and also incorporating the multilateral resistance terms.

5.4. Empirical results

5.4.1.Model estimation

In a first stage, the parameters of the gravity model in equation (9) were estimated with Ordinary Least Squares (OLS) and Poisson Pseudo-Maximum Likelihood (PPML) estimators (Silva and Tenreyro 2006), taking account of the clustering of the error terms within groups.[13] Failure to account for clustering could result in understated standard errors (Moulton 1990), i.e. errors are more likely to be correlated by country pair. The MTR terms are included in the model estimation by specifying the transport infrastructure and connection variables of interest using equation (10).

The PPML approach is a generalised linear model method for estimating gravity. It uses quasi-Poisson distribution and a log-link. The advantage of this approach is that zero trade flows are allowed in the estimation. In the OLS approach, we add unity to the trade values that are equal to zero to avoid the zero trade flows being dropped (as the trade is transformed into a logarithmic form).

Table 8 presents the model results. Models 1 and 2 are baseline gravity models including distance, tariff and other control variables.

In models 1 and 2, most of the terms are significantly estimated with the expected sign. The distance and tariff terms are negatively estimated, implying that the greater the distance between the trading partners, the smaller the trade flows.

For both the OLS and PPML approaches, distance is a trade deterrent, although the elasticity is smaller in the PPML model. A common border between the trading countries has a positive effect on export flows, as do colonial ties. A common language also has a positive effect on export levels, although this is only identified in the OLS estimates.

Models 3 and 4 show the estimated parameters including transport connectivity (distance by mode) and transport infrastructure quantity and service. The signs of the estimates do not differ between the OLS and PPML approaches, except for the tariff term, which is (incorrectly) positively estimated in the OLS model.

13 The models were estimated using the STATA software package.

Table 8 Preferred econometric results from gravity model

	Model_1		Model_2		Model_3		Model_4	
Estimated Method	OLS		PPML		OLS		PPML	
Dependent Variable	Log (exports+1)		Exports		Log (exports+1)		Exports	
Description	coef.	t-value	coef.	t-value	coef.	t-value	coef.	t-value
Exporter GDP	0.827	78.91	0.523	27.98	0.450	47.19	0.380	34.83
Importer GDP	0.512	52.58	0.503	39.94	0.202	20.71	0.404	35.69
Distance[14]	-2.083	-74.99	-0.757	-17.9				
No rail connection (constant)					-0.976	-7.78	-0.624	-3.04
Air distance					-0.878	-9.33	-0.457	-4.76
Maritime distance					-0.432	-5.56	-0.149	-2.08
LPI of exporter					18.526	15.69	0.417	4.41
Road density					0.953	21.07	0.263	5.1
Rail density					0.170	6.02	6.744	16.4
Tariff	-0.003	-3.47	-0.013	-1.6	0.011	4.93	-0.009	-4.6
Common border	-0.332	-2.38	0.459	2.3	1.387	14.94	0.956	6.87
Common language	0.128	1.49	0.077	0.62	0.563	15.37	-0.025	-0.22
Colonial history	1.799	11.95	0.112	0.95	12.043	30.05	0.076	0.59
Obs.	9,485		9,485		9,485		9,485	
Adjusted / (pseudo)R^2	0.951		0.497		0.958		0.553	

Notes: The models are based on cross-country data from 2013. T-values are calculated using the ratio between each coefficient and the clustered standard errors. T-values > 1.96 indicate that the coefficient is statistically significant at the 95 per cent confidence interval; t-values > 1.65 indicate that the coefficient is statistically significant at the 90 per cent confidence interval. We checked the multicollinearity using the STATA vif command.

5.4.2. Transport connectivity and trade facilitation

With regard to transport connectivity, we find that a lack of rail connection between the trading partners has a strong negative impact on bilateral trade. This might be explained by the fact that a lot of the BRI countries (25 per cent) are landlocked and heavily rely on road/railway transport for international trade. For these nations, land transport infrastructure is important to ensure a smooth and reliable shipping of goods. After several attempts, we were unable to obtain any significant estimate of rail distance in the model (this may be partly correlated with the 'No rail connection' parameter).

14 Distance in the baseline model is sourced from the CEPII geodistance database.

Air distance and maritime distance are both significantly and negatively estimated. This implies that with the reduction of distance between trading country partners, bilateral trade will improve and the impact is statistically significant. The impact of transport connectivity on total exports is shown in Table 9. Adding a rail connection between trading partners in the study area leads to an average increase of trade by 2.8 per cent. We also find that a 10 per cent reduction in air and maritime distance increases trade by 0.4 per cent and 0.1 per cent, respectively.

Table 9 Sensitivity test of the impact of transport connectivity on export trade volumes

Change of transport indices	Change in trade
Added rail connection	2.8 per cent
Air distance reduced by 10 per cent	0.41 per cent
Maritime distance reduced by 10 per cent	0.13 per cent

Baniya et al. (2017) calculated that with a BRI rail connection, trade in a previously non-connected region would increase by between 1.3 per cent (lower band, for consumers only) and 13 per cent (upper band, for both consumers and producers). Our results are in line with their findings at the lower band value. Herrero and Xu (2016) found a 10 per cent reduction in air and maritime distance would lead to an increase of trade by 5.5 per cent and 1.1 per cent, respectively, which is much higher than our estimates. We suspect that the difference is caused by the different set of variables included in the trade model. For our study, apart from the journey time, we have also included the transport infrastructure indices, which may absorb some effect of the trade variation among countries.

In Hummels (2001b), the elasticities of transport costs with respect to distance are 0.46 (air), 0.39 (rail), 0.275 (road) and 0.22 (sea). The summary in Abe and Wilson (2009) concludes that the elasticity is higher by land than by sea. In our study, the order of magnitude is generally in line with the previous empirical evidence.

5.4.3. Transport infrastructure and trade facilitation

With regard to transport infrastructure, we found that LPI of exporter, road density of both exporter and importer (the sum of the two) and rail density of both exporter and importer (the sum of the two) were all positively estimated with a significant impact. This implies a positive relationship between transport infrastructure and total trade. We also calculate the impacts of improving transport infrastructure on total exports. These are shown in Table 10. A 10 per cent increase in road and rail density would increase the total trade volume by 0.34 per cent and 0.21 per cent, respectively.

Table 10 Sensitivity test of the impact of infrastructure on export trade volumes

Change of transport indices	Change in trade
Road density improved by 10 per cent	0.34 per cent
Rail density improved by 10 per cent	0.21 per cent

Airport density and LSCI are dropped from the model as they become less significant (this might be due to collinearity with other variables such as air distance or LPI).

Interestingly, the importance of transport connectivity (represented by distance as a proxy for transport cost) is not diminished when the transport infrastructure and service quality indices are included. This also indicates that, like transport services between borders, the transport infrastructure within the trading countries (behind borders) is important for the fast and reliable delivery of goods to the respective market.

We find that tariff barriers have a significant negative effect on trade. The higher the tariffs set by the country of destination, the lower the level of exports.

With regard to the other country control variables, if the trading partners share a common border, language or colonial history, they are more likely to engage in trade with each other. However, the impact of having the same language and colonial history becomes less significant in the model based on the PPML estimates.

In summary, we find that both transport connectivity between the trading partners (in terms of distance by modes) and transport infrastructure are linked with a significant increase in bilateral trade. In the following section, we predict the potential impact on trade and the economic effects of the improving transport connectivity and infrastructure in the BRI region.

5.5. Predicting the impact of improving transport in the BRI region on trade

We use model 4 to predict the impacts of transport infrastructure improvement on the total trade in the BRI region. One challenge for forecasting the impacts is that the BRI is still in its early phases and the detailed plan and projects are not yet publicly available. It is therefore difficult to estimate how much the transport connectivity will change. However, the finalised project plan could provide some hints on the potential changes. Again, we emphasise the preliminary nature of the gravity model (discussed earlier) and that the results should be taken as order-of-magnitude estimates only.

With regard to railway transport, a few BRI projects are ongoing. For example, 1,702 freight trains were operated between China and 15 European cities in 2016 (Josephs 2017), which is more than double the 2015 figure. Using rail, the journey time from central China to Europe is reduced from over 30 days (by maritime transport) to less than two weeks. This will be further reduced to three to four days with improvements in railway facilities and train speed.

In South Asia, the initiative encourages its partners to continue pursuing the connectivity agenda in line with their national priorities, and it supports multilateral connectivity projects such as the Asia Highway Network Agreement and the Trans-Asia Railway Agreement (TAR)[15] by providing political support, investment guidance and cross-border facilitation.

15 The project was first initiated in the 1950s, with the objective of providing a continuous 14,080 km rail link between Singapore and Istanbul, Turkey, with a possible connection to Europe and Africa. The project promised to significantly reduce the shipping time and cost between Europe and Asia. However, progress in developing the TAR was hindered by economic and political obstacles throughout the 1960s till early this century (*Trans-Asian Railway* 2018).

China has already financed and built a US$4bn railway between Djibouti and Addis Ababa, Africa's first transnational electric railway. In Kenya, a Chinese firm has built a new railway connecting Nairobi to the country's port city of Mombasa. Eventually it will reach Uganda, Rwanda and the Democratic Republic of Congo. Ultimately, the initiative fosters the development of domestic and intercountry rail links in the BRI region.

With regard to maritime transport, transport cost savings stem from improvements in efficiency in ports. In the port of Qingdao, efficiency improvements have led to cost reductions of around 5 per cent. In the long term, as part of the initiative, new ports will be built in Djibouti, Myanmar, Bangladesh, Sri Lanka and Pakistan. After the completion of these projects, the maritime network will be changed significantly. Together with other transport modes, maritime distances and costs will be reduced.

With regard to air transport, of the 193 Chinese civil aviation construction projects planned for 2015, 51 strategic projects, totalling US$32bn, directly serve the BRI initiative. Over the past two years, China has constructed 15 new airports and expanded 28 existing ones that have direct links with countries connecting China to Europe via Central Asia (Han 2015).

The models estimated in section 5.4 provide essential input for examination of a set of the policy scenarios. Based upon the on-going BRI project information, we have simulated a series of policy scenarios and examined the impact of improving transport connectivity and infrastructure within the BRI region and in the wider study area.

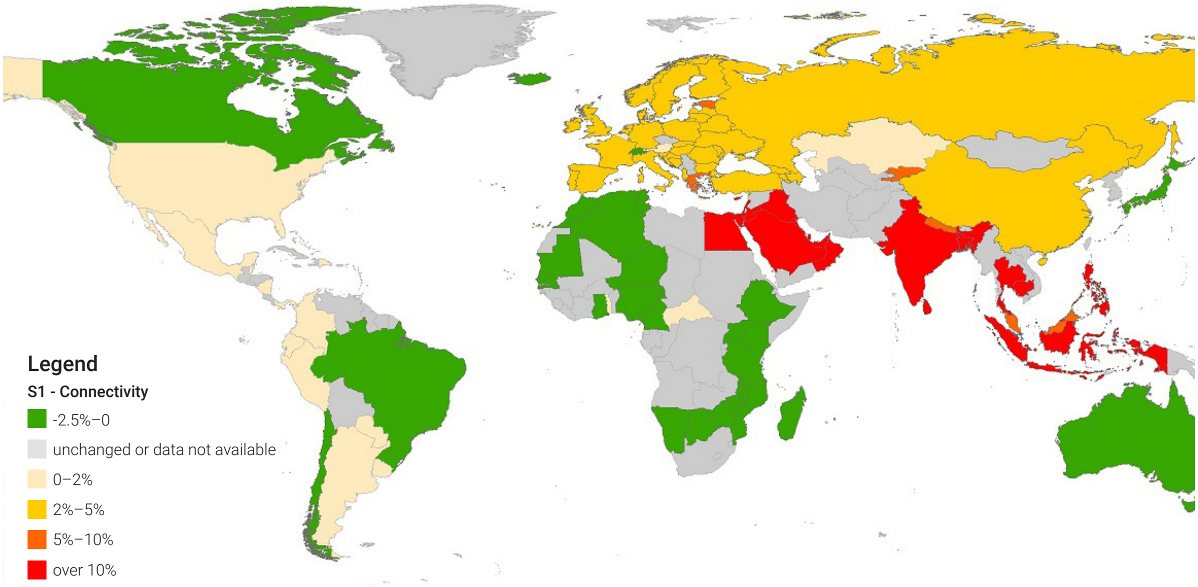
5.5.1. Scenario test 1: Improving transport connectivity in the BRI region

In the first scenario, we assume that all the countries within the BRI have rail connections and that the maritime cost decreases by 20 per cent to reflect the new maritime routes and improvement in efficiency. As a result, Europe and countries across the BRI region would all have rail connections in this scenario.

As mentioned above (sections 5.2 and 5.3), MTR terms are incorporated into the model to capture the fact that export from one country to another is determined by trade costs across all possible export and import markets. In this way, bilateral trade flows are determined by relative trade costs rather than solely by absolute trade costs between the trading partners. Omitting the MTR in the model would lead to an upward bias in predicting trade gains.

The results for the first simulation test are shown in Figure 8.

Figure 8 Scenario test 1 on the impact of improved transport connectivity (distance) on total exports (% change)



Source: produced by the authors based on the analysis

We observe relatively high percentage increases in total exports in South and West Asia and North Africa with the assumed improvement of transport connectivity in the BRI region. As discussed in subsection 4.1.3, these regions currently suffer from poor rail connections. Land transport is an important element for intranational and regional trade. The scenario test shows that the improvement of rail connections in the BRI region would lead to trade gains for most of the countries in the BRI region, especially those that have previously suffered from a lack of rail connections. The high percentage change in some countries is partly a result of the relatively small economies of these countries currently. A small increase in the total exports would lead to a higher percentage change.

On the other hand, we observe relatively small gains and some small reductions in trade in some of the EU member states and other countries. The reductions may be a result of improved rail connections within the BRI region, which lead to more trading where previously the connectivity between countries was fairly poor.

We judge this finding to be plausible, but it needs to be treated with caution. There are significant uncertainties in the BRI project: for instance, some of the details around infrastructure improvements, for example regarding routes and project timescales, are not yet known, but will affect trade transport costs. In addition, the model only estimates the direct, static impact of transport connection improvements on trade. However, improved transport connections will improve the efficiency of the producers/factories and the whole supply chain. Therefore, our results are likely to be in the lower range and are likely to underestimate the impact.

5.5.2. Scenario test 2: Improving transport infrastructure in the BRI region

In the second scenario, we test the impact of improving transport infrastructure and service quality within the BRI region. First, we test improving the rail and road density by ten per cent. Second, we test improving the LPI by two per cent. We modelled the impact of rail and road density of both exporter and importer countries based on the assumption that the impacts on the trade are the same.[16] For the overall logistics service quality, we incorporated the exporter's LPI into the model as we could not find any significant impact of the importer's LPI.

Figure 9 shows the impact of the improvement in the transport infrastructure and service quality of the trading partners (if one of them is in the BRI region). Again, we find that:

- The Asia region and countries in North Africa see the most improvement in exports.
- The percentage increase is relatively small compared to that of the improvement in rail connectivity.
- Some relatively small increases can be seen for some other countries.[17]

A ten per cent improvement in the transport infrastructure and a two per cent increase in the LPI in the BRI countries would increase the trade in the Eurasian region. We observe an average increase of two to five per cent for countries in the BRI region and a smaller increase in the European countries (up to two per cent).

Shepherd et al. (2011) estimated the impact of a five per cent multimodal transport infrastructure improvement on trade in the OECD countries as between two and five per cent. Our result is generally in line with this finding.

The impact of infrastructure improvement is smaller than that of the improvement of transport connectivity, although we managed to estimate both impacts from the trade model. This indicates that – as with transport services across borders – the transport infrastructure within the trading countries is important for fast and reliable delivery of goods to the respective market. Trading economies benefit from improvement of the transport infrastructure in their country.

Again, we emphasise that the results should be treated with caution due to the uncertainties in the BRI project. In addition, the infrastructure improvements are just one element of the BRI project; the reduction of trade and financial barriers and other forms of international cooperation are likely to contribute to the deepening of trade and economic relations among countries in the BRI region. Therefore, our results may represent a conservative estimate.

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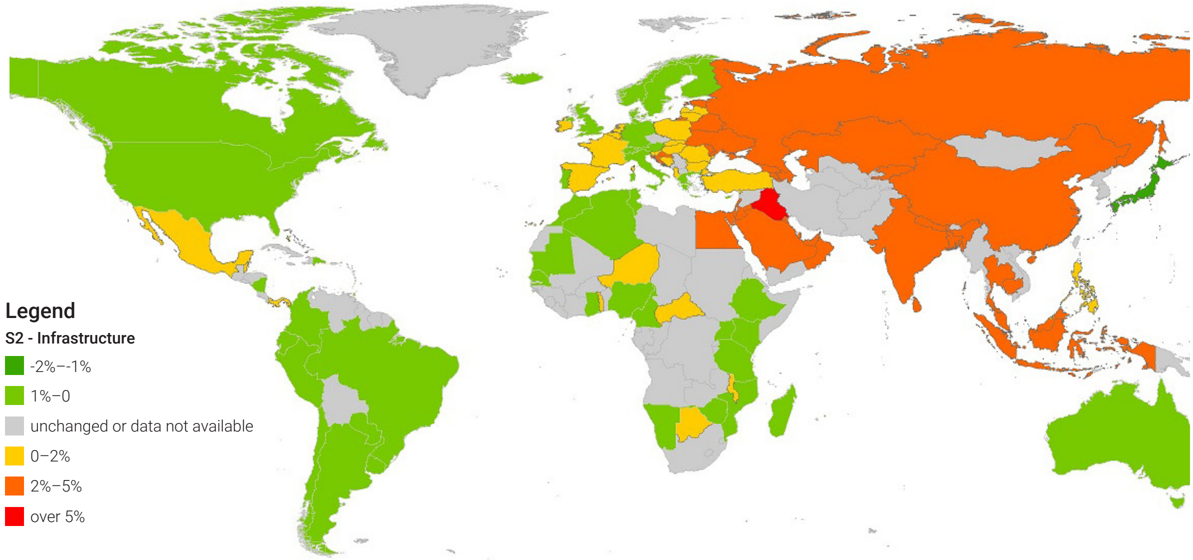
16 Nordas and Piermartini (2004) found that exporters' infrastructure is more important than that of importers.

17 This can partly be explained by if one of the country partners is within the BRI region, in this scenario, the transport infrastructure improvement in the country within the BRI region would lead to the trade gain between the trading partners. Therefore, we observe some relatively small increases in the countries outside of the BRI region.

Figure 9 Scenario test 2 – the impact of improved transport infrastructure and service quality on total exports (% change)



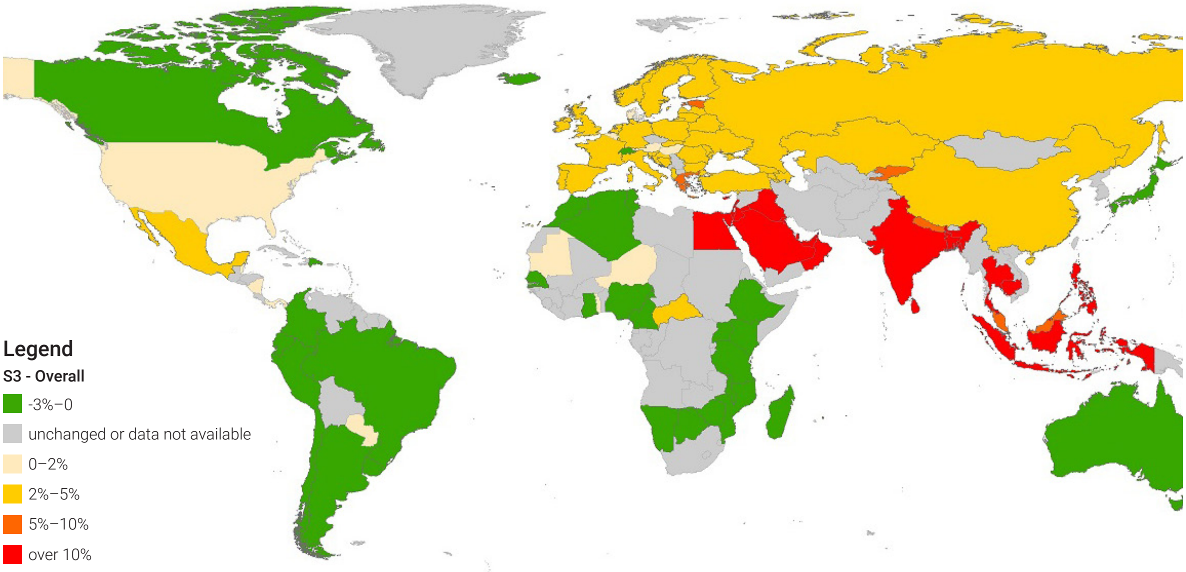
Source: produced by the authors based on the analysis

5.5.3. Scenario test 3: Effect of improving transport connectivity and infrastructure

In the third scenario, both the transport infrastructure and connectivity are improved (a combination of scenario 1 and scenario 2). The simulation results are shown in Figure 10.

- We observe relatively strong improvements in trade in the West and South Asia regions. The high percentage is partly a result of the relatively small economies in these countries.
- We find increases in trade in East Asia (China).
- We observe small gains in trade and some small losses of trade in Central Europe and other countries.

Figure 10 Scenario test 3 on the impact of improved transport connectivity and infrastructure on total exports (% change)



Source: produced by authors based on the analysis

5.5.4. Summary of the scenario tests

Table 11 and Table 12 summarise the scenario testing results by percentage change and absolute total export value changes, by region.

Table 11 Predicting the impact of improving transport connectivity and infrastructure on total exports by region (% change)

	S1 - Connectivity	S2 - Infrastructure	S3 - Connectivity and Infrastructure
BRI region	6.6%	3.3%	7.3%
EU	2.5%	0.1%	2.6%
All countries in study area	3.2%	1.1%	3.5%

Table 12 Predicting the impact of improving transport connectivity and infrastructure on total exports by region (US$bn)

	S1 - Connectivity	S2 - Infrastructure	S3 - Connectivity and Infrastructure
BRI region	296	149	329
EU	128	7	133
All countries in study area	397	139	429

Figure 11 and Figure 12 show the predicted change in trade by different regions.

We observed a slightly bigger impact on trade of improving transport connectivity in the BRI countries (scenario 1) compared to improving transport infrastructure (scenario 2).

Overall, we find that with the improvement of transport infrastructure and connectivity in the BRI region trade volumes increase in both the BRI region and the EU. Not surprisingly, the BRI region sees the highest increase in trade. Overall, the total trade volumes increase by US$329bn for the BRI region and US$133bn for the EU.

Figure 11 Scenario test results: impacts of improving transport infrastructure and service quality on total exports by region (percentage change)

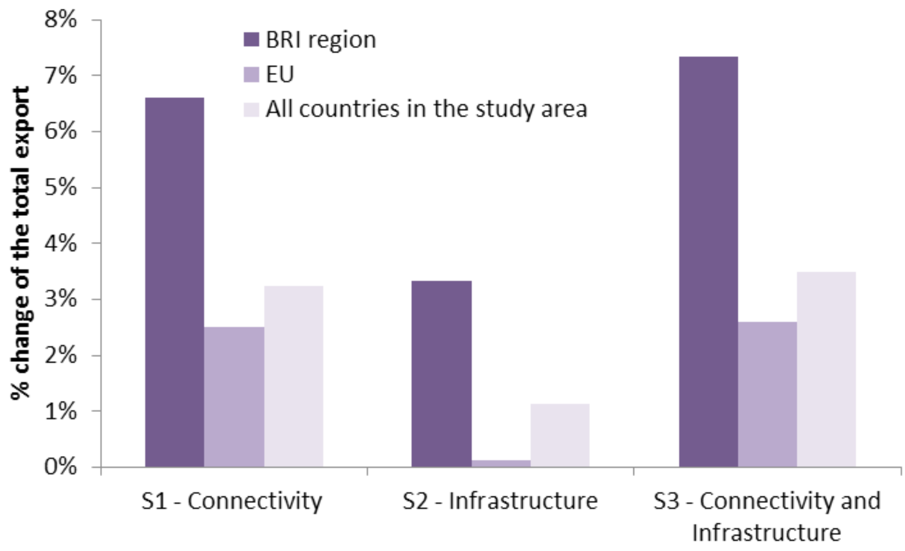
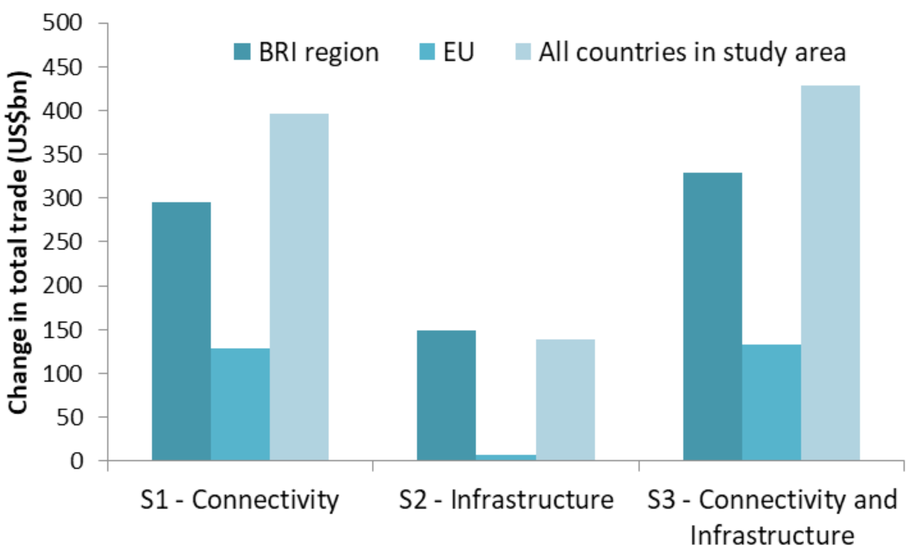


Figure 12 Scenario test results: impacts of improving transport infrastructure and service quality on total exports by region (absolute change US$bn)



6 Summary and conclusions

6.1. Summary of the findings

The findings of the literature review show that multimodal transport infrastructure and connectivity is key to boosting international trade and economic growth. More specifically, good transport infrastructure reduces transport cost and facilitates trade expansion. Efficient transport infrastructure facilitates the industrialisation process and enables more efficient regional and global production networks, supports regional integration and fosters development and regional and national welfare.

This study identified and discussed physical and soft barriers and facilitators related to transport connectivity and trade and more generally in the BRI region. The physical barriers/facilitators include inadequate capacity of infrastructure and equipment, speed and cost of transporting goods and inhospitable terrain; the soft barriers/facilitators include legal and regulatory barriers, project financing, security and tracking of goods and security surrounding trade routes. The findings highlight that barriers could become facilitators, if resolved.

Building upon the findings from the qualitative analysis, we formed our research hypothesis: that removing the physical barriers (by improving transport infrastructure and connectivity) would facilitate trade and have a wider positive impact on economic growth in the BRI region.

To test the research hypothesis, we constructed a gravity model, testing the relationship between transport connectivity and infrastructure and trade. First, a series of indices were constructed to measure transport infrastructure (including rail/road density, airport density and logistics performance) and transport connectivity (using distance by different modes as a proxy of journey cost). We included countries in the BRI, EU countries and a few other countries to allow us to understand the impact of transport infrastructure and connectivity both within the BRI region and more widely.

The descriptive analysis of the transport measures finds that:

- Transport infrastructure in the BRI region (road density, rail density and airport density) is less dense than in other countries.
- Within the BRI region, there is variation in the level of transport infrastructure across countries. We observed that some countries in South and West Asia suffered from poor rail/road connectivity between countries/regions and a relatively low road/rail density in some areas.

Then, a gravity model was developed to estimate the impact of transport infrastructure and connectivity on bilateral trade within the study area. To capture the relative trade cost among trading countries, we incorporated the MTR terms in the modelling framework.

We have found a positive relationship between transport infrastructure and connectivity and bilateral trade. The impact is statistically significant. Additionally, in the BRI region, having a rail connection was found to have the largest impact on improving trade (improving total exports by 2.8 per cent in the study area). This was followed by improvements in the road and rail density of the trading countries. Logistics performance (for instance LPI) also showed a significant and relatively strong impact on bilateral trade flows.

The importance of transport connectivity (represented by distance as a proxy for transport cost) is not diminished when the transport infrastructure and service quality indices are included. This indicates that, in addition to transport services across borders, transport infrastructure within the trading countries (behind borders) is also important for the fast and reliable delivery of goods to the respective market.

Simulation tests enable us to predict the impact of transport improvements on trade under different transport improvement assumptions. Overall, we observe that with the proposed level of improvement of the transport infrastructure in the BRI region, total trade volumes increase not only in the BRI region, but also in the EU and other countries. Therefore, improving transport infrastructure appears to present a win-win scenario in terms of the impact on trade.

6.2. Caveats and future research

This is a proof-of-concept study and targeted at stimulating discussion and providing empirical evidence on the order of magnitude of transport infrastructure improvements in the BRI region. We hope that the findings will be of use to policymakers and stakeholders who are interested in this infrastructure plan. Below, a few caveats of the study (which also indicate the need for further research) are discussed:

6.2.1. The study could be improved by the use of panel data (when available)

The empirical model is based on cross-country data from 2013. Results from the empirical model show associations between transport cost and bilateral trade rather than causal relationships. The model would be significantly improved by the use of panel data (when available). Such data would help us to control a wider range of external factors, which could support the robustness of the model estimation results. For instance, Storeygard (2016) uses longitudinal fuel cost and cross-sectional transport infrastructure quality to measure transport costs between cities in sub-Saharan Africa.

Our model reflects the aggregate impact of transport connectivity and infrastructure on trade levels. It would be valuable to explore how the impact of transport connectivity and infrastructure on trade varies across different sectors. For instance, agriculture products may have different sensitivities to transport compared with manufacturing sectors. Furthermore, the work could be extended to model the impact in specific regions or economic corridors with the BRI.

In our model, transport distance is used as a proxy for measuring transport cost. Ideally, journey time, monetary costs and aspects of transport service quality (such as reliability, frequency), by mode, would be used to better represent true transport costs and capture competitiveness across modes. However, this data is not widely available. In addition, the study could be extended to better reflect true networks of the different modes of travel to better understand the true costs of shipping by different modes and to predict the impact of improvements in infrastructure across the different available modes of travel, again, ideally for different sectors.

6.2.2. The model could be extended to quantify the wider impacts of transport infrastructure on exports.

Due to the preliminary nature of the gravity model, we cannot explicitly model wider economic responses, for instance, how producers and consumers would react as a second-order response to the improvement of transport facilities. In addition, it would also be good to incorporate in the model the responses of other economic elements such as factories, inventories, logistics chains and consumers to understand the wider economic impact and achieve an economic equilibrium. Ideally, this work should be extended using a Computable General Equilibrium (CGE) model to quantify the wider impact of transport improvement on trade and national economies. The modelling analysis could then explore a range of investment scenarios, further investigating the sensitivity of a wider range of assumptions.

6.2.3. The study could be extended to incorporate the impact of other barriers and facilitator.

From the desk research, we identified a number of other barriers and facilitators – for instance, financial risks, security issues and political uncertainties and wider environmental impacts – which could all have a significant impact on transport infrastructure investment and trade. In the current study, we are unable to incorporate all of these. Ideally, we would extend our model to analyse a range of scenarios exploring which investments are robust across a range of future assumptions.

6.3. Policy implications

The study shows that transport infrastructure and service quality remain key constraints in countries in the BRI region. This lack of infrastructure provision inhibits trade development within this region and between it and other countries/regions. Investing in trade- and transport-related infrastructure such as ports, airports, roads and rail links and connections should remain a priority and sufficient funding should be made available for this purpose. This could be a challenge for countries with lower GDP levels. There should be scope for economies to work together on a regional or subregional basis to conquer this challenge. In this sense, the BRI can play an important role by providing investment to the BRI regions that most need it.

Countries/regions across the BRI region should coordinate their transport infrastructure development plans and seek to facilitate cooperation. For instance, the EU has developed the 'Trans-European Transport Policy (TEN-T)', which aims to ensure smooth and seamless transport of goods and passengers in the single market, with plans to extend the route to neighbouring countries. One of the main aims of the BRI is to enhance transport connectivity between Asia and Europe. It is essential for countries and regions in both continents to coordinate their development plans to achieve compatibility and complementarity between their policies and the implementation of infrastructure plans. In this context, it is encouraging to see that the EU–China connectivity platform (European Commission 2017) has been established to improve the coordination between the two parties on transport connectivity.

Finally, trade facilitation measures can be considered along two dimensions: ‘physical’ infrastructure (i.e. roadways, railways, airports and maritime ports, explicitly discussed in our quantitative modelling work in section 5) and ‘soft’ infrastructure (regulatory, institutional, project management-related, etc., as discussed in the qualitative work in section 3). Both are important for trade. Under the BRI, significant infrastructure funding is invested in physical infrastructure projects aiming to improve regional connectivity to reduce transport costs and enhance trade; however, other measures relating to soft infrastructure should accompany these investments to ensure the initiative delivers sustained economic, social and environmental benefits. In this context, it is encouraging to see that China is working with the United Nations Development Programme (UNDP) to seek to ensure the implementation of the BRI facilitates the attainment of the Sustainable Development Goals (SDGs) (UNDP/China Center for International Economic Exchanges 2016).

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Appendix A: Country list of the study area

Table A-1 Country list of the study area[18]

Region		Name	ISO3	Name	ISO3
EU (28)		Austria	AUT	Italy	ITA
		Belgium	BEL	Latvia	LVA
		Bulgaria	BGR	Lithuania	LTU
		Croatia	HRV	Luxembourg	LUX
		Cyprus	CYP	Malta	MLT
		Czech Republic*	CZE	Netherlands	NLD
		Denmark	DNK	Poland	POL
		Estonia	EST	Portugal	PRT
		Finland	FIN	Romania	ROU
		France	FRA	Slovakia	SVK
		Germany	DEU	Slovenia	SVN
		Greece	GRC	Spain	ESP
		Hungary	HUN	Sweden	SWE
		Ireland	IRL	United Kingdom	GBR

18 * denotes countries that were not included in the model analysis due to lack of data for trade or transport indices.

Region		Name	ISO3	Name	ISO3
BRI (65)	East Asia	China	CHN	Mongolia*	MNG
	South-East Asia	Brunei	BRN	Philippines	PHL
		Cambodia	KHM	Singapore	SGP
		Indonesia	IDN	Thailand	THA
		Laos*	LAO	Timor-Leste*	TLS
		Malaysia	MYS	Vietnam*	VNM
		Myanmar*	MMR		
	Central Asia	Kazakhstan	KAZ	Turkmenistan*	TKM
		Kyrgyzstan	KGZ	Uzbekistan*	UZB
		Tajikistan*	TJK		
	Middle East	Bahrain*	BHR	Palestine*	PSE
		Egypt	EGY	Oman	OMN
		Iran*	IRN	Qatar	QAT
		Iraq	IRQ	Saudi Arabia	SAU
		Israel	ISR	Syria*	SYR
		Jordan	JOR	United Arab Emirates	ARE
		Kuwait	KWT	Yemen*	YEM
		Lebanon	LBN		
	South Asia	Afghanistan*	AFG	Maldives	MDV
		Bangladesh	BGD	Nepal	NPL
		Bhutan*	BTN	Pakistan*	PAK
		India	IND	Sri Lanka	LKA
	Europe and North-West Asia	Albania	ALB	Lithuania	LTU
		Armenia	ARM	Macedonia*	MKD
		Azerbaijan	AZE	Moldova	MDA
		Belarus	BLR	Montenegro*	MNE
		Bosnia and Herzegovina	BIH	Poland	POL
		Bulgaria	BGR	Romania	ROU
		Croatia	HRV	Russia	RUS
		Czech Republic*	CZE	Serbia*	SRB
		Estonia	EST	Slovakia	SVK
		Georgia	GEO	Slovenia	SVN
		Hungary	HUN	Turkey	TUR
		Latvia	LVA	Ukraine	UKR

Region		Name	ISO3	Name	ISO3
Other countries (45)		Algeria	DZA	Mauritius	MUS
		Argentina	ARG	Mexico	MEX
		Australia	AUS	Morocco	MAR
		Bahamas	BHS	Mozambique	MOZ
		Belize	BLZ	Namibia	NAM
		Botswana	BWA	Nicaragua	NIC
		Brazil	BRA	Niger	NER
		Cameroon	CMR	Nigeria	NGA
		Canada	CAN	Panama	PAN
		Central African Republic	CAF	Paraguay	PRY
		Chile	CHL	Peru	PER
		Colombia	COL	Senegal	SEN
		Dominican Republic	DOM	Seychelles	SYC
		Ecuador	ECU	Switzerland	CHE
		Ethiopia	ETH	Tanzania,* United Republic of	TZA
		Fiji	FJI	Togo	TGO
		Ghana	GHA	Trinidad and Tobago	TTO
		Iceland	ISL	Tunisia	TUN
		Japan	JPN	Uganda	UGA
		Kenya	KEN	United States of America	USA
		Madagascar	MDG	Uruguay	URY
		Malawi	MWI	Zimbabwe	ZWE
		Mauritania	MRT		

Appendix B: Examples of bilateral distance by different transport model

Table B-1 Examples of bilateral distance by different transport model (km)

Origin	Destination	Maritime Distance (CERDI)	Aviation distance	Rail/Road distance	CEPII Geo distances
China	Germany	22,324	7,395	8,679	7,785
China	Spain	18,945	9,250	11,801	9,232
China	France	17,632	8,248	9,854	8,225
China	Russian Federation	13,118	5,855	6,832	5,795
Germany	Belgium	958	656	805	197
Germany	France	4,917	890	1,124	440
Germany	Turkey	6,785	2,099	3,313	2,038
Spain	Belgium	3,229	1,342	2,008	1,317
Spain	France	2,482	1,064	1,632	1,055
Spain	Italy	2,034	1,380	2,239	1,367
France	Belgium	4,403	296	321	262
France	Italy	1,287	1,135	1,422	1,110
France	Russian Federation	5,800	2,507	3,023	2,494
France	India	9,916	6,614	9,994	6,594
Kazakhstan	Germany	10,076	3,941	4,647	5,148
Kazakhstan	Spain	7,641	5,733	7,169	6,423
Kazakhstan	France	7,371	4,812	6,064	5,562
Kazakhstan	China	6,786	3,719	5,539	3,277
India	China	11,522	3,830	5,852	3,785
India	Germany	14,391	5,809	9,656	6,230
India	Cambodia	7,049	3,477	4,106	3,445

Appendix C: Relationship between exports and transport indices

Figure C-1 Correlation between exports and airport density (2013)

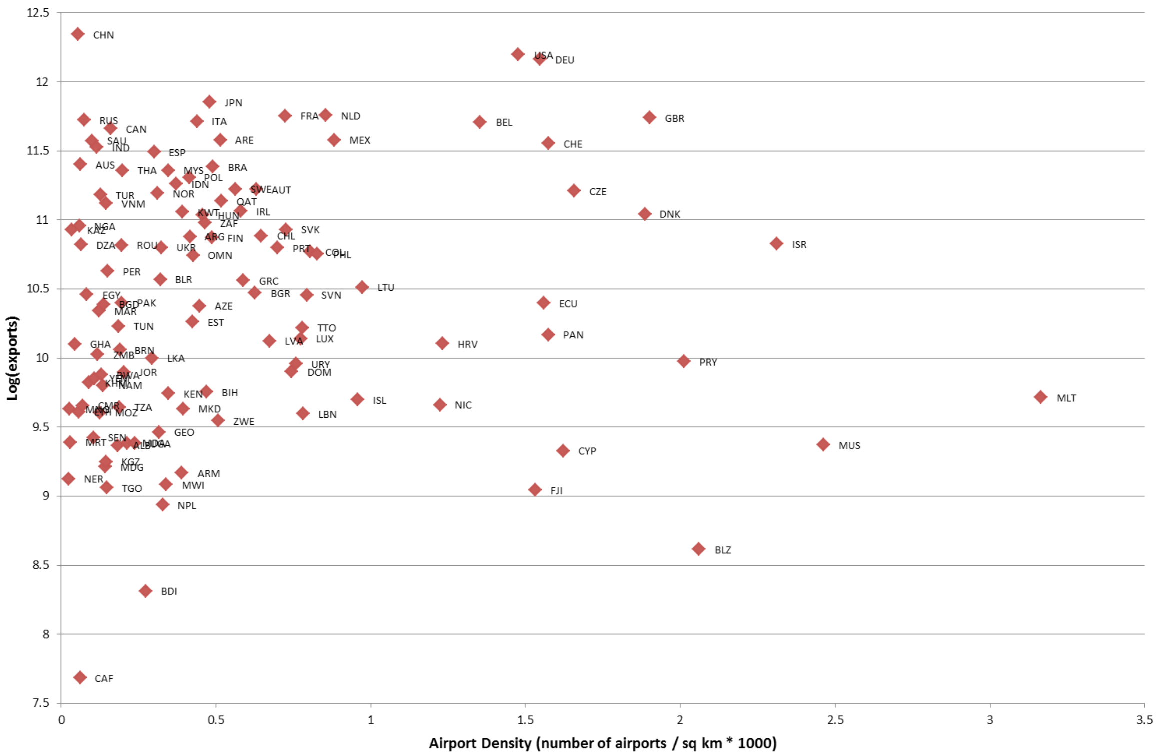


Figure C-2 Correlation between exports and road density (2013)

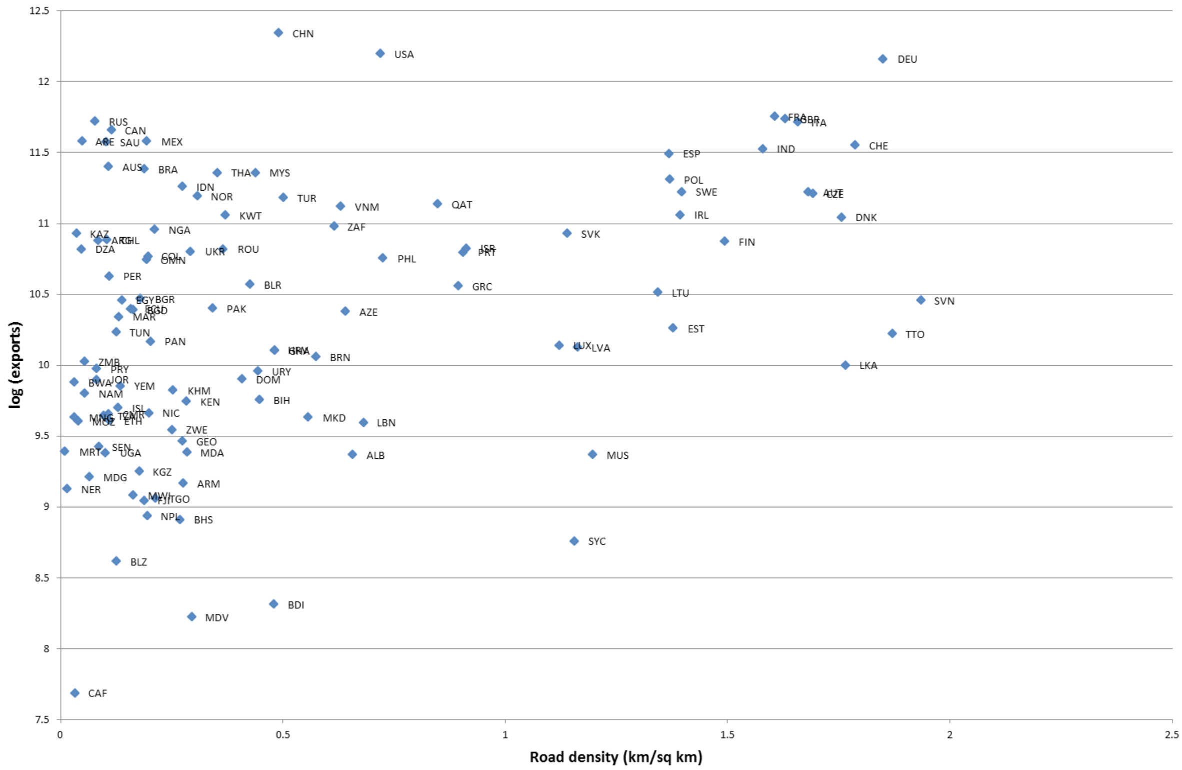


Figure C-3 Correlation between exports and railway density (2013)

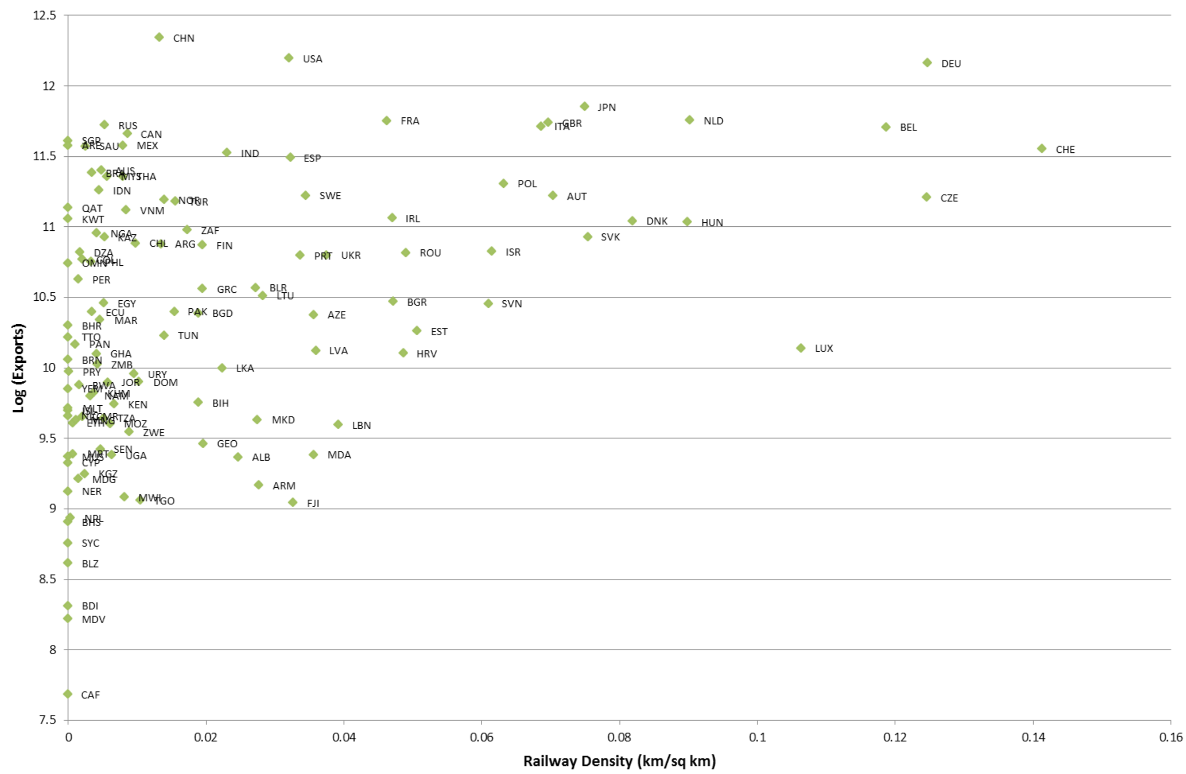


Figure C-4 Correlation between exports and LPI (2013)

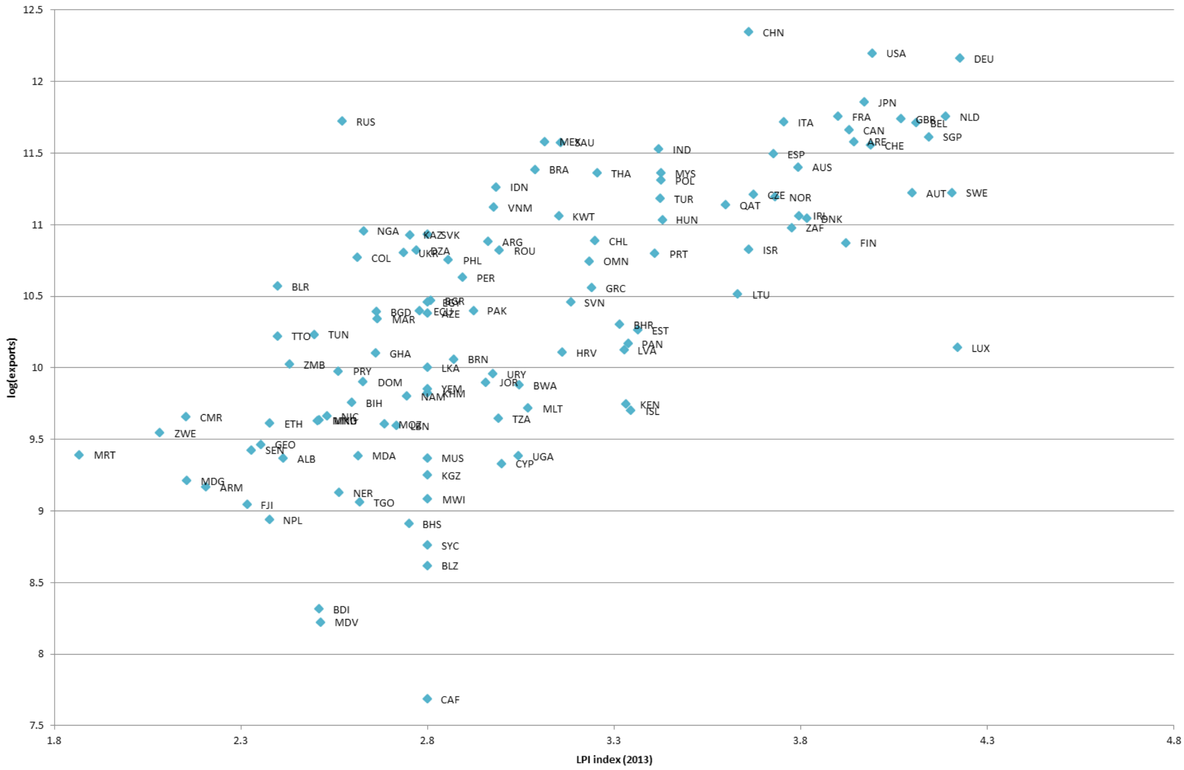
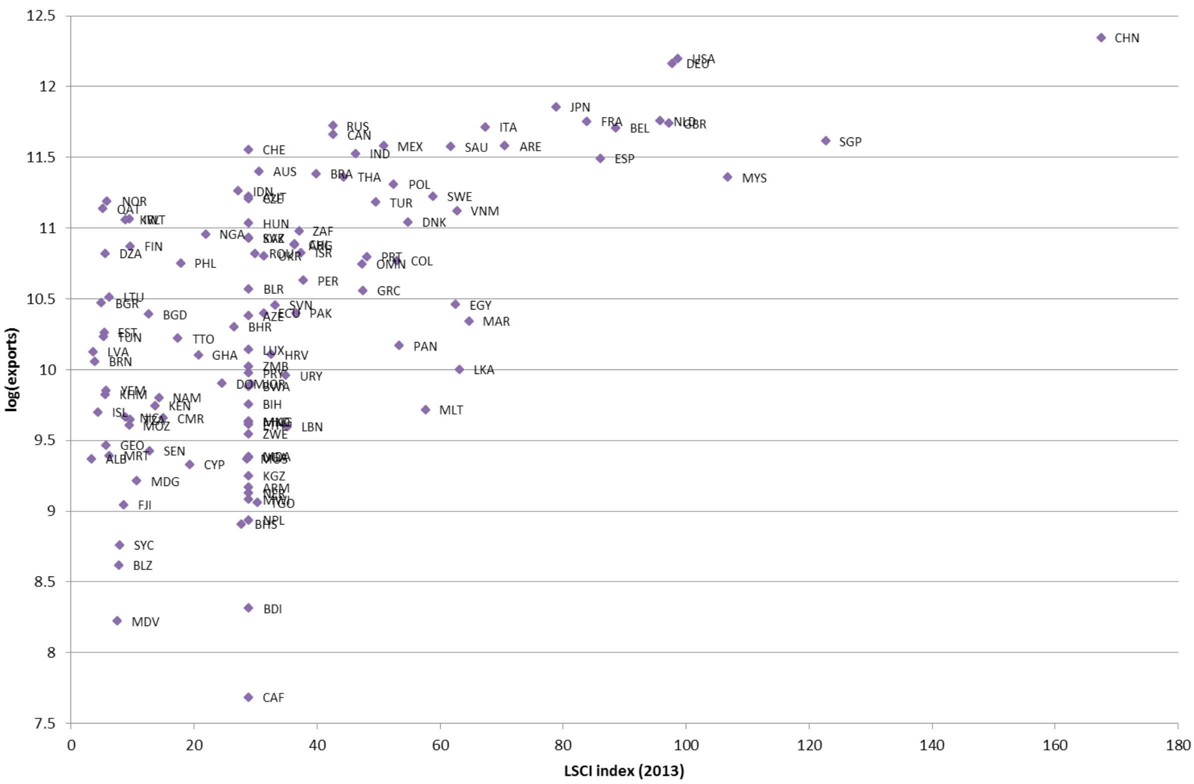


Figure C-5 Correlation between exports and LSCI (2013)



About the authors

Dr Hui Lu is a senior analyst at RAND Europe. Her research interests are in transport economics and behaviour analysis. She has extensive experience in transport economics evaluation and modelling for major transport infrastructure for national and international clients, for example valuation of high speed train and toll roads. She has more than 10 years' experience in behaviour analysis and works in transport, consumer demand, telecoms, postal economics, health and social care and technology sectors.

Charlene Rohr is a senior research leader at RAND Europe. Her research interests are in understanding factors that influence mobility and travel, using quantitative and qualitative methods. She has more than 25 years of experience developing econometric models to predict travel demand at urban, regional and national levels. In the UK, she has led two rapid evidence reviews to explore the impact of social and economic factors and technology on travel demand.

Marco Hafner is a senior economist and research leader at RAND Europe working on employment, education and social policy research. He has particular expertise in data analysis and econometrics, having undertaken extensive quantitative research in the topics of labour, trade and international economics. He provides expert economic analysis on projects for public and private clients, including the European Commission and Parliament, and the World Bank.

Anna Isabela Knack is a research assistant at RAND Europe. Her research experience covers future foresight, innovation policy, and the impact of emerging technologies on society. She has extensive experience in comparative country case study analysis, semi-structured interviews, literature reviews, survey analysis and desk-based research.