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How Much Will the Belt and Road Initiative Reduce Trade Costs?

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Abstract

This paper studies the impact of transport infrastructure projects of the Belt and Road Initiative on shipment times and trade costs. Based on a new data on completed and planned Belt and Road transport projects, Geographic Information System analysis is used to estimate shipment times before and after the Belt and Road Initiative. Two sets of data are computed to address different research questions: a global database based on an analysis of 1,000 cities in 191 countries and 47 sectors and a regional database that focuses on more granular information (1,818 cities) for Belt and Road economies only. The paper uses sectoral estimates of "value of time" to transform changes in shipment times into changes in ad valorem trade costs at the country-sector level. The findings show that the Belt and Road Initiative will significantly reduce shipment times and trade costs. For the world, the average reduction in shipment time will range between 1.2 and 2.5 percent, leading to reduction of aggregate trade costs between 1.1 and 2.2 percent. For Belt and Road economies, the change in shipment times and trade costs will range between 1.7 and 3.2 percent and 1.5 and 2.8 percent, respectively. Belt and Road economies located along the corridors where projects are built experience the largest gains. Shipment times along these corridors decline by up to 11.9 percent and trade costs by up to 10.2 percent. The paper also shows that these effects are magnified by policy reforms that reduce border delays and improve corridor management.

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How Much Will the Belt and Road Initiative Reduce Trade Costs?[1]

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1. Introduction

The Belt and Road Initiative (BRI) is a development strategy proposed by China that focuses on connectivity and cooperation on a trans-continental scale. It roughly follows and expands the old Silk Road on the land side and complements it with a maritime part to build a series of economic corridors with the goal of boosting trade and stimulating economic growth across Asia, Europe and Eastern Africa.[2] The range of initiatives and activities that will be part of the BRI is very wide, including policy coordination, infrastructure, trade and investment, financial and people-to-people exchanges. In this paper, we focus on the consequences of transport infrastructures linked with the Belt and Road Initiative and quantify the associated decrease in shipment times and ultimately trade costs. We build two new databases with estimates of trade cost changes across sectors and country-pairs and provide an analysis of the systemic impact that the BRI may have on trade costs for all countries in the world.

The new databases presented in this paper are composed of two sets of data that can be used to address different research questions. The global database contains information based on an analysis of 1,000 cities in 191 countries and 47 sectors. The regional database contains the same variables but focuses on the 71 economies that are part of the Belt and Road Initiative and is computed with a higher degree of granularity.[3] In particular, the focus on fewer countries allows to include in the analysis a larger number of cities.

In terms of method, we first use a combination of geographical data and network algorithms to compute the reduction in shipping times between all city pairs in our analysis. As a starting point, we use the current network of railways and ports across the world and employ a shortest path algorithm to compute an estimate of the current shipping times between every pair of cities. We use assumptions regarding the average speed for different transportation modes as well as data for the processing time when reaching a port or when crossing borders. From this reference point, we run a series of “improved scenarios”, where the transportation network is enriched with all planned infrastructure projects that are linked to the Belt and Road Initiative. We show that by increasing the number of rail and port connections and by improving the speed and processing times for improved rail segments and ports, the Belt and Road Initiative can significantly contribute to decreases in shipping times between a large number of city-pairs in BRI economies as well as in many other countries.

A complex issue is how to deal with the possible switch of transport modes once BRI infrastructure projects are completed. In computing the shipping times post-BRI, we consider two alternative

[2] The Belt and Road Initiative is structured around two main components, (i) the Silk Road Economic Belt (SREB), and (ii) the 21st Century Maritime Silk Road (MSR). More specifically, the “Belt” links China to Central and South Asia and onward to Europe, while the “Road” links China to the nations of South East Asia, the Gulf Countries, East and North Africa, and on to Europe. Those parts are themselves organized around six economic corridors: (1) the China-Mongolia-Russia Economic Corridor; (2) the New Eurasian Land Bridge; (3) the China–Central Asia–West Asia Economic Corridor; (4) the China–Indochina Peninsula Economic Corridor; (5) the China-Pakistan Economic Corridor; and (6) the Bangladesh-China-India-Myanmar Economic Corridor.

[3] There is no official list of countries in the Belt and Road Initiative. For this study, we focused on a list of 71 economies (Annex 1). Countries in the list should be interpreted as economies that are geographically located along the Belt and Road as proposed by China.

specifications in order to build a lower bound and an upper bound for our estimates. In the lower bound scenario, we prevent mode switching between the pre-BRI and the post-BRI shipping routes so that the decreases in shipping times are solely driven by a denser network of links. Under this assumption, the average decrease in shipping time is 1.2 percent across all country pairs. In the upper bound scenario, we allow for mode switching, so that some trade routes can move from maritime links to rail-based links and hence experience a larger gain in shipping time. In this scenario, the decrease in shipping time at the world level reaches 2.5 percent. Overall, our results underline the importance of network effects in transportation and feature a wide geographical dispersion in the benefits from the BRI. Indeed, our estimated gains are spread across the world, with all countries experiencing a decrease in shipping time with at least one of their partners. BRI economies experience a decrease in shipment times ranging between 1.7 and 3.2 percent on average. The largest estimated gains are for the trade routes connecting East and South Asia. We also find that shipment times along economic corridors fall substantially, ranging between 3.6 percent for the China-Mongolia-Russia Economic Corridor (CMREC) to 11.9 percent for the China-Central Asia-West Asia Economic Corridor (CCWAEC).

We then use Hummels and Schaur (2013) sectoral estimates of "value of time" to transform reductions in shipping time into reduction in ad-valorem trade costs. Since Hummels and Schaur's (2013) estimates are very disaggregated (at the HS2 or HS4 level), we need to aggregate them for each country pair using appropriate trade weights. We work with 47 sectors based on the Global Trade Analysis Project (GTAP) categorization and excluding services. Since each of those sectors contains many HS2 or HS4 categories, the composition of trade flows within each GTAP sector differs across country pairs. Hence, we compute the "value of time" for each pair of countries and GTAP sector to reflect the actual composition of each sector within each origin-destination flow. These country pair-sector values of time can be further aggregated to quantify changes in trade costs by country.

The results combining our GIS network analysis and the ad-valorem conversion suggest that implementing all BRI transport infrastructure projects will result in a large decrease in trade costs for many countries. For the world, the reduction of aggregate trade costs ranges between 1.1 percent in the lower bound scenario and 2.2 percent in the upper bound scenario. For the BRI economies, the change in trade costs will range between 1.5 and 2.8 percent, under the lower and upper bound scenario respectively. As for shipping times, the gains in trade costs exhibit significant heterogeneity across pairs of countries, with East Asia and Pacific as well as South Asia being the regions with the larges average reductions. Finally, trade costs have the sharpest drops along corridors, ranging between 2.4 percent for the China-Mongolia-Russia Economic Corridor (CMREC) and 10.2 percent for the China-Central Asia- West Asia Economic Corridor (CCWAEC).

The focus of this paper is the impact of BRI-related transport infrastructure projects on shipment times and trade costs. But the Belt and Road Initiative includes efforts to improve the efficiency of customs, reduce border delays or to improve management of economic corridors. As an extension of our main database, we present two scenarios where those elements are explicitly taken into account. We find that the implementation of complementary policy reforms magnifies the impact on shipment times and trade costs, especially along the corridors. For instance, if border delays were reduced by half, the reduction of shipment times along corridors would range between 7.7 percent for the China-Indochina Peninsula Economic Corridor (CICPEC) and 25.5 percent of the China-Central Asia-West Asia Economic Corridor

(CCWAEC). Similarly, trade costs would fall by 5.6 percent for the China-Indochina Peninsula Economic Corridor (CICPEC) and by 21.6 percent for the China-Central Asia-West Asia Economic Corridor (CCWAEC). These large effects are not surprising given the importance of trade facilitation bottlenecks in BRI economies (Bartley Johns et al., 2018).

Our paper relates to several strands of literature. First, the importance of time as a trade barrier has been studied extensively in the literature and the heterogenous sensitivity of products to shipment delays has been documented in a number of papers including Hummels (2001), Hummels, Minor, Reisman, and Endean (2007), Djankov, Freund and Pham (2010), Hummels and Schaur (2013) and Baniya (2017). Second, several recent studies have analyzed the trade effects of infrastructure projects either within or across countries (Donaldson, 2018; Duranton, Morrow and Turner, 2014; Alder, 2017). Third, a subset of this literature also relies on georeferenced data and GIS analysis to assess the trade and the spatial effects of transport infrastructure (e.g. Roberts, Deichmann, Fingleton and Shi, 2010; Volpe Martincus, Carballo and Cusolito, 2017). By providing precise estimates of the potential decrease in trade costs expected from the Belt and Road Initiative, our databases are being used as inputs in papers assessing the potential implications of the BRI for trade flows, foreign investment, GDP and welfare (e.g. de Soyres, Mulabdic and Ruta, 2018; Baniya, Rocha and Ruta, 2018; Maliszewska, van der Mensbrugghe and Osorio-Rodarte, 2018; Chen, 2018; Bird, Lebrand and Venables, 2018).

The paper is organized as follows. Section 2 presents the database on BRI transport projects and the methodology used to measure shipping times. Results of the network analysis are presented in Section 3, while the impact of the BRI on trade costs is analyzed in Section 4. Section 5 presents two extensions of the analysis. Concluding remarks follow.

2. Network analysis: Method and assumptions

The Belt and Road Initiative covers a large number of transport projects in many countries. The consequences of implementing all those improvements is a priori very hard to forecast: for example, the benefit from building a new segment of rail might depend on the construction or upgrade of a new port at the end of the rail when joining the coast. Furthermore, the optimal route between two cities might depend on the implementation of several projects, which means that one cannot study transport infrastructures independently from one another. The interconnectedness of all elements in the transportation network poses a challenge to any researcher trying to estimate the changes in trade costs that can reasonably be gained from the BRI.

In order to embrace the complexity of network effects while at the same time taking into account all planned BRI transport projects and all countries in the world, our analysis is based on an estimation of shipping times. Specifically, our goal is to develop and implement a structured method to compute the shipping time between all city pairs in the world before the BRI and after the implementation of all identified BRI transport projects. This section presents our methodology and assumptions in detail.

a. Overall method

As a starting point, we build a network model which takes into account in a precise way the current transportation network and we use it to compute shipment times between all city-pairs using a shortest path algorithm. From this reference point, we run multiple “improved” scenarios that account for the planned infrastructure projects linked to the BRI and we assess the reduction in shipping times resulting from these projects. The list of projects we consider and the associated assumptions for the computation of shipment time is described in the next sub-section.

We carry out the analysis using a GIS software which allows us to precisely map the current transportation network and then to enrich it with the planned infrastructure improvements that can be linked to the BRI. In particular, we use ArcGIS Network Analyst which provides network-based spatial analysis tools for solving complex routing problems. A network solution involves finding the shortest path between two locations, where the length or cost of a path is the total accumulated shipping time computed along the optimal path.

In our analysis, we focus on rail and maritime links, abstracting from road and air connectivity, which allows to simplify the network analysis. Two main reasons justify this approach. First, as discussed in detail below, the large majority of BRI transport projects consist of rail and maritime infrastructure. Second, most international trade travels by sea and, to a smaller extent, by rail. Maritime shipping accounts for 80% in volume and 70% in value of global trade (OECD, 2017) and rail is the second transportation mode used, while only a small portion of international trade travels by road and air. GTAP data indicate that for BRI countries the percentage of international shipments by water and land is around 90%. According to shipping data, this fraction is even higher for China.[4]

The nodes of our network in the global database, which serve as both origin and destination in the analysis, are all cities with population greater than 500,000,[5] as well as the two most populous cities in each country (data permitting). This creates a total of 1,000 cities and includes 34 cities with reported population less than 50,000. In our regional database, we use all cities above 100,000 inhabitants within the BRI countries under consideration, which leads a total of 1,964 cities in 71 economies. The network is solved for each origin-destination pair, with routing determined by shortest time path, adjusting for preference parameters.[6]

The use of a network analysis to quantify shipment times and the impact of new and improved transport infrastructure has benefits and drawbacks. On the plus side, a network analysis can be a useful tool to support modeling of international trade flows. It can enhance the understanding of the impact of changes in infrastructure or other factors on an interconnected system allowing to extract information from spatial data. Specifically, a network analysis allows to obtain realistic measures for the time it takes to go from one location to another taking into account the overall quality and quantity of infrastructure, physical

[4] See Annex 2 for more data on modal shares in the world and in the BRI countries. Air shipment represents a small fraction in terms of trade volume, but a larger one in terms of value since it concerns goods with higher value on average.
[5] Population sources are https://www.citypopulation.de/world/Agglomerations.html and http://data.un.org/Data.aspx?d=POP&f=tableCode%3A240
[6] To “attach” cities to elements of the transportation network (a rail segment or a port), a fuzzy tolerance of 10km was used. As a result, any city located more than 10km away from any network element is left as unconnected and de facto excluded from the results.

obstacles (e.g. rough terrain) or other barriers (e.g. border delays), and relative performance measures (e.g. processing time at ports or when crossing a border).

As with any modeling exercise, it should be noted that our network is a simplified version of reality and results are affected by the quality of inputs. For example, we do not include some elements that could affect routing, such as rail gauge, freight or passenger lines, service frequency, etc. An additional limitation that needs to be acknowledged comes from the fact that the Belt and Road Initiative includes some efforts that are not easily introduced to the network: improving efficiency of customs, special economic zones, reducing border delays or an improved management of economic corridors. As an extension of our main database, in Section 5 we present two scenarios where those elements are explicitly taken into account. Finally, our results are driven by a number of assumptions regarding the speed along different path as well as the choice of transportation mode, the processing time when reaching a port and the time it takes to cross a border. We describe those assumptions in detail below.

b. Transport network and BRI-related transport infrastructure projects

We start with an initial network of links connecting all cities considered in our analysis, and we then add additional links and improved speed corresponding to transport infrastructure projects that are linked to the Belt and Road Initiative. Our initial network comes from Delorme Atlas of the Earth (DAE), 2015 release. For our analysis, maritime features were generated separately for the Pacific, Atlantic and Indian Oceans, and for the Caribbean Basin and Seas of Indonesia. To simulate plausible trans-oceanic shipping routes, great-circle arcs[7] were generated from port locations along the boundary of Exclusive Economic Zones. Within the Caribbean Basin, around Indonesia, and near land, connectivity to major ports was manually digitized using a map of Global Shipping Routes (ESRI, CIA, 2012).

When building our estimates of shipping time reductions that can be associated with the BRI, we need to enrich the current transportation network with planned projects. Compiling a list of transport infrastructure projects associated with the BRI is a delicate task since there is no one criterion that could be used to define what is or is not part of the initiative. In particular, there might be projects financed by loans from China that might not necessarily fall under the BRI, and there might be projects with non-Chinese funding that are still considered in some sources as being part of the BRI.

We start from the list of infrastructure projects developed by Reed and Trubetskoy (2018) and which considers projects respecting all three following criteria:

1. The project is explicitly mentioned in one of the following sources as being part of BRI: either document issued by a government (including government press agencies), or article in a major academic journal or global news source or a quote by a government official in a reputable news source.
2. The project is at least in the planning phase.
3. The project impacts travel between two cities of at least 300,000 inhabitants.

These criteria present the advantage of restricting our list to projects that have been indeed related to the BRI and to exclude some projects for which feasibility might be in question. For example, condition 2

[7] Shortest distance between two points on the surface of a sphere, measured along the surface of the sphere.

excludes the Moscow-Beijing high speed rail or the Bering Strait connection, which were proposed but have no real plans. Moreover, condition 3 excludes small road projects in Cambodia that are clearly not along any shortest path linking major cities.

We then simplify the list of projects from Reed and Trubetskoy (2018) and keep only the rail and maritime elements. Then, to ensure consistency with the information on the ground, we validate it with the help of World Bank country teams. As a result, the exact list of all projects used in the analysis and sources can be found in Table A1 in annex. We then geo-localize each of these projects in our map and generate links with the current rail lines, ports and maritime links, which creates a denser transportation network on which we can run our shortest path algorithm.

Beyond the data by Reed and Trubetskoy (2018), other sources of information on BRI investment have been compiled elsewhere and might have different inclusion criteria. One example is the WIND BRI database, which gathers China's Oversea Direct Investment (ODI) projects in BRI countries. Compared to the data used in our paper, this source is both more restrictive along certain aspects as it contains only projects that are associated with ODI, and at the same time more extensive in the sectoral coverage. Moreover, it comprises planned projects for which ODI amounts have been announced, which is likely to be more restrictive than our definition. Note that some projects still appear in both our list and the WIND database, such as the Malaysia East Coast Rail Link Project or the Moscow-Kazan High Speed Rail Project. Another example of alternative source is the database collected by Reconnecting Asia at the Center for Strategic and International Studies (CSIS)[8] which includes transportation projects (roads, rails, ports, bridges and tunnels) as well as other elements such as electrification projects of special economic zones in Asia.

c. Working assumptions

The multimodal network used in this analysis was constructed by merging two types of features: maritime and rail.[9] These features are largely non-overlapping and separated in space. The shortest path algorithm is used to find the shortest routing (in terms of shipping time) between any city-pair in our network and taking into account all possible ways to link the origin city to the destination city. In order to find such optimal route, each network element is associated with a time cost which is accumulated along the route to sum up to the total shipping time. Time is then calculated as the segment length divided by speed, where the speed of distinctive features is presented in

Table 1.

Table 1: Speed assumption for different transport modes

Description	Pre-BRI	Post-BRI

[8] The database is available online at https://reconnectingasia.csis.org/

[9] On top of rail and maritime networks, there are a few particular cases where we added road segments for cities characterized by extremely low or inexistent rail connectivity. This happened in exactly 8 cases for the following cities: Osh (Kyrgyzstan), Kabul (Afghanistan), Thimpu (Bhutan), Kigali (Rwanda), Guatemala City & Mixco (Guatemala), San Salvador (El Salvador), León & Managua (Nicaragua) and Belmopan (Belize). In those cases, we used a speed of 25km/h for the associated road segment.

Maritime	25 km/h	25 km/h
Upgraded rail	50 km/h	75 km/h
New rail	–	75 km/h

The choice of transportation mode is difficult to model and follows different logics and trade-offs which are specific to the sector under consideration. It depends on the different elements that affect shipping costs such as the bulkiness of the good, subsidies, oil price, market structure and many others that cannot be modeled in a sensible way in our analysis. To account for the very high share of maritime shipping in international trade, we use a network preference to produce a maritime alternative where land connectivity exists. Within the optimal path algorithm, this preference is implemented in the following way: for any city pair that has access to both a maritime and a rail link, the algorithm selects the maritime option whenever the shipping time is lower than four times the shipping time incurred using the rail link. While such a criterion can be seen as a strong simplification of the actual trade-off faced by many logistic companies, the imposition of such a preference for maritime links allows us to have a representation of the world that is very much in line with other data sources in terms of both modal shares and total shipping times at the city-pair level. For example, in our pre-BRI scenario with the global database, maritime transportation represents a total of 82.3% of all trade routes. In the following sub-section, we explain in detail how we deal with the possibility of mode switching once all BRI projects are implemented.

On top of the time cost computed along the network elements, we account for processing times when a shipment is reaching / leaving ports, based on the estimates in Slack, Comtois, Wiegmans and Witte (2018). In their paper, Slack et al (2018) use data from Lloyds Intelligence Unit and base their estimates on a sample of 17,024 vessels in 2013. In our network, we use their regional averages reported in Table 2. In the context of our analysis, these processing times correspond to a “penalty” incurred when reaching a port, either from the land and from the sea, and correspond to the time it takes to load or unload the goods. In the improved scenario, when a project involves building a new port or upgrading an old port, we assume that the associated “processing time” decreases according to the following rule:

Improved Port Delay = Max (0.5*Baseline port Delay, Lowest Worldwide Processing Time)

This rule allows us to account for a proportional decrease in port delay of 50 percent with a limit that no port can be more efficient than the worldwide lowest estimate of 17.2 hours.

Table 2: Processing time in ports as estimated by Slack, Comtois, Wiegmans and Witte (2018)

Region	Mean Ships Time In Port (hours)
Central and South America	23.5
South and South-East Asia	26.5

East and North Asia	17.2
Gulf and Red Sea	26.8
Mediterranean	20.3
Northern Europe	29.5
North America – East Coast	21.1
North America – West Coast	46.2
South Africa	64.6

Finally, processing time when crossing an international border is also an important part of overall shipment time for international trade. To account for border delays in our computations, we include importing and exporting time from the "trading across borders" section in the World Bank's Doing Business Database.[10] The data is available for each country considered in our analysis and Table 3 presents the average values aggregated by region. To get bilateral values for border delays for each directed country-pair, we compute the total border delay as the sum of importing and exporting time for each origin and destination respectively. Whenever a border is crossed along the optimal route, the "border penalty" is incurred.

Table 3: Export and Import processing time at the border (from the Doing Business Database)

Region	Time to export: Border compliance (hours)	Time to import: Border compliance (hours)
East Asia & Pacific	55.9	70.5
Europe & Central Asia	28	25.9
Latin America & Caribbean	62.5	64.4
Middle East & North Africa	62.6	112.3
South Asia	59.4	113.8
Sub-Saharan Africa	100.1	136.4

d. Reality-check: How do our pre-BRI estimates compare with other sources?

In the previous subsections, we presented the method and assumptions we used to construct estimates of shipping time between city-pairs across the world. We now ask the following question: how do our estimates before the BRI compare with other sources of information regarding shipping time? This allows us to verify the adequacy of our working hypothesis, in particular regarding the speed along different network elements, the border delays and the port processing time. While those estimates cannot be

[10] For any border, we use the data on "Border Compliance" and the total delay is assumed to be the sum of export time from the exporting country and the import time from the importing country. We do not include documentary compliance as it does not relate to travel time. All data are available at: http://www.doingbusiness.org/data/exploretopics/trading-across-borders

compared with actual data for all city-pairs because such data are not available, it is still possible to compare our figures for specific city-pairs using various sources.

In Table 4, we corroborate our results using data from Tan and Reja (2018). In this paper, the authors conducted interviews with China based companies and collected information regarding the time it takes to ship products by train for certain destinations. While still featuring some differences, our pre-BRI figures are broadly consistent with the quotes from private companies.

Table 4: Comparison between shipment time declared by survey participants (Tan and Reja (2018)) and our "pre-BRI' results.

	Survey	Our "Pre-BRI" scenario
Lanzhou to Almaty	10 days	8.95 days
Lanzhou to Astana	10 days	8.40 days
Manzhouli to Yekaterinburg	9 days	-
Qiqihar to Yekaterinburg (Qiqihar is 650km east of Manzhouli)	-	12.2 days

Note: This table focuses on rail links

Along the same lines, Table 5 presents a comparison between our own estimates and quotes that can be found online from a company specialized in maritime transportation.[11] Again, we find that our estimates are not far from the information we can gather from private companies, which is another validation of the method and the assumptions used.

Table 5: Comparison between commercial information and our "pre-BRI' results.

	CFC	Our "Pre-BRI" scenario
Dalian to Hamburg	34 days	34.04 days
Shanghai to Antwerp	32 days	32.32 days
Guangzhou to Bremen	29 days	32.40 days
Shanghai to Rotterdam	27 days	32.41 days

Note: This table focuses on maritime links. Commercial information comes from CFC: cargofromchina.com.

3. Effects of the Belt and Road Initiative on shipping times

In this section, we present the results on shipment times from the network analysis before and after the Belt and Road Initiative. We first construct two scenarios: a lower bound scenario, where exporters cannot switch mode of transport after the BRI infrastructure projects are completed, and an upper bound

[11] See at https://cargofromchina.com/china-europe/

scenario where the transportation mode can change. Then we proceed to estimate the effects of the BRI on shipping times under these two scenarios.[12]

a. The lower bound scenario

Recognizing that choices of transportation mode do not only take into account shipment time but also shipment costs and other considerations, we build our main estimates of reduction in shipment time by avoiding large changes in transport mode before and after the BRI. These are conservative estimates as the new BRI infrastructure might actually induce some firms to substitute maritime link in favor of rail links which might be more expensive but also significantly faster. By not considering these changes, the estimates should be interpreted as the minimum gains in terms of shipping time that can be achieved by taking advantage of all new and upgraded transport links but without any change in the transportation mode.

In the previous section, we showed that the network analysis results in the pre-BRI scenario are in line with other data sources both in terms of city-pair shipping times and in terms of aggregate modal shares. Taking those results as a starting point, we build a first post-BRI scenario where the shares of maritime and rail transportation modes would not exhibit significant change for each city-pair. To do so, we use a two-steps procedure. We provide here an intuitive description of our method and give a more detailed explanation in the annex.

We proceed in two steps. First, we run a network analysis with all BRI transport projects taken into account and find the optimal shipping route between all city-pairs, keeping our maritime preference as in the pre-BRI computation. Second, for each origin-destination, we compute the share of maritime and rail in the optimal path and compare them to the modal shares from the pre-BRI scenario. If the optimal route after the BRI features a change in the modal share lower than 5%, we keep the result as is since there is no major shift in transportation mode. If, instead, the optimal route features a modal switch above 5%, we run additional scenarios and change the preference for maritime links until we find a shipping route post-BRI that keeps the transportation mode unchanged.

The procedure described above allows us to obtain results at the city-pair level where before and after BRI travel time can be compared in a sensible manner. It should be emphasized that this lower bound scenario indeed corresponds to a conservative estimate since exporters benefit from an improved network but they cannot take advantage of those improvements to change their transportation mode. Figures 1 and 2 below show two examples of routes before and after the BRI where there is no significant mode switch – and which therefore are part of the lower bound analysis. In Figure 1, we can see that the shipping route between Beijing and Dushanbe goes through rail links both before and after the

[12] One difficulty of such a network analysis is the association of each city with an "entry point" in the transportation network – usually referred to as "snapping". Because cities are never exactly located on the network, we need to specify a snapping tolerance when performing this step. Since we compare two scenarios (*before* and *after* the BRI), we also need to make sure each city is associated with the same snapping unless there is a new network element in their surroundings. To ensure we do not have inconsistencies between scenarios, we compare the snapping and manually exclude all cities featuring difference between scenarios. The number of cities quoted in the paper (1,000 in the global database and 1,964 in the regional database) reflects the cities selected through this procedure and which are actually used in our analysis.

implementation of BRI transport projects. It is apparent from the map that the construction of new rails shortens the route between those cities. In addition, the route contains "upgraded" parts (not shown in the figure) where the rails are not new but the speed along some segments is enhanced as part of the BRI.

Figure 1: Shipping route before and after the BRI between Beijing and Dushanbe – Lower Bound analysis.

Note: The yellow line is the "pre-BRI" route while the red line corresponds to the "post-BRI" route.

Figure 2, based on the link between Beijing and Tehran, presents an example of shipping route that is mostly maritime both before and after the BRI. By construction of the lower bound scenario, we do not allow the optimal path to switch to a rail-based route in the "post-BRI" scenario and we consider only the decrease in shipping time coming from new or upgraded links with a given transportation mode. The example in Figure 2 also shows the importance of the Kra Canal in Thailand, which is a project associated with a significant amount of uncertainty and whose actual execution is far from being certain.

Figure 2: Shipping route before and after the BRI between Beijing and Tehran – Lower Bound analysis.

Note: The light blue line is the "pre-BRI" route while the dark blue line corresponds to the "post-BRI" route.

b. The upper bound scenario

As an alternative to our conservative estimates, we now turn to the construction of an upper bound scenario of the changes in shipment time that can be achieved through the Belt and Road Initiative. In building the upper bound scenario, our goal is to allow changes in transportation mode once the BRI projects are taken into account so that new and upgraded rail links might divert some routes away from long maritime routes towards shorter rail connections.

One difficulty of our method based on a shortest path algorithm with a preference for maritime links is that if we simply remove the preference for maritime links in the post-BRI computation we might observe city-pairs using shorter rail links even in the absence of any BRI changes. In other words, if we just remove the constraint of maritime preference, some changes in optimal route and transport mode will happen independently on whether there is a BRI project or not. It would therefore be misleading to input those changes as BRI improvements.

We deal with this issue in the following way: first, we compare the modal shares in the pre-BRI setup with and without maritime preference. This allows us to identify city-pairs where the modal switch from maritime to rail occurs even without any network improvements. For such city-pairs, we keep the result from our lower bound scenario, since we cannot say that the modal choice change is due to BRI projects. We are then left with city-pairs that did not experience a switch in transportation mode when we remove the maritime constraint: for those links, we run a post-BRI scenario without preference for maritime links and keep the results unchanged in the case the optimal route after the BRI involves a higher share of rails compared to the pre-BRI scenario.

Figure 3: Shipping route before and after the BRI between Beijing and Tehran – Upper Bound analysis.

Note: The light blue line is the "pre-BRI" route while the red line corresponds to the "post-BRI" route.

Figure 3 presents an example of such a case: the link between Beijing and Tehran experiences a dramatic change in the transportation mode when we compare before and after the BRI. In our upper bound scenario, we keep such a large gain in shipment time because we know such a switch could indeed be triggered by BRI-related network improvements.

c. Results from the global and regional databases

Based on the method detailed above, we estimate reductions in shipment time between all the pairs of cities considered in our analysis. To aggregate all values at the country-pair level, we take a population-weighted average of the city-pair reductions to compute country-pair level values. More precisely, we first compute the total population of each city-pair by summing the population of origin and destination cities, and then use this total population as weights in the country-pair aggregation. We do this exercise for our global database -using a total of 1,000 cities in 191 countries- and for the regional database -covering 1,964 cities and 71 economies. We present first the results of the global database and then discuss the main differences with the regional database.

Our first step is to look at the changes in the average shipping time before and after the BRI for the world. Before the BRI, the average shipping time for all country-pairs is 22.9 days. This declines to 22.6 and 22.3 days in the lower and upper bound scenarios, respectively. The proportional reduction in shipping time ranges between 1.2 and 2.5 percent. In other words, the BRI is expected to contribute to a decrease in shipping times of 7 to 15 hours across all country-pairs in the world. It is important to note that this average is taken with respect to all possible country pairs in the world, some of which are not or very little affected at all by the BRI.

To have a better sense of the consequences of the BRI we aggregate the results across pairs of regions.[13] Looking at the figures in Table 6, one can notice several interesting patterns. First, as expected, the East Asia and Pacific region is experiencing the largest decrease in shipping times vis-à-vis all the other regions (first column in Table 6). The highest gains are between the East Asia and Pacific and South Asia, with the average gains reaching 4.67 percent when aggregating across all country pairs. Second, while not all pairs of regions are expected to have gains (there is no change in shipping time between North America and the Latin America), every single region will benefit with at least some of their partners. As an example, it is worth noting that the Latin America and Caribbean region is expected to decrease the shipping time by 1.15 percent with countries in the South Asia region.

At a more disaggregated level, the results also feature significant heterogeneity when looking across country-pairs (Figure 4 and Figure 5). For example, among the top ten countries experiencing the largest decrease in shipping time with China, there are countries in Asia (Kirghizstan, Bangladesh, Malaysia) but also countries in Africa (Tanzania, Mauritius, Kenya). These results show why it is important to use a network approach in order to understand the interconnections of all planned infrastructures: the gains in Kenya are the results of the infrastructure in both Kenya and in several countries in Asia. The benefits from the Lamu port and LAPSSET rail corridor in Kenya are magnified by the rails in Myanmar, Thailand and Pakistan as well as the port projects in Kyaukpyu (Myanmar) and Gwadar (Pakistan).

Table 6: Proportional decrease in shipment time, aggregated by regions – Lower Bound.

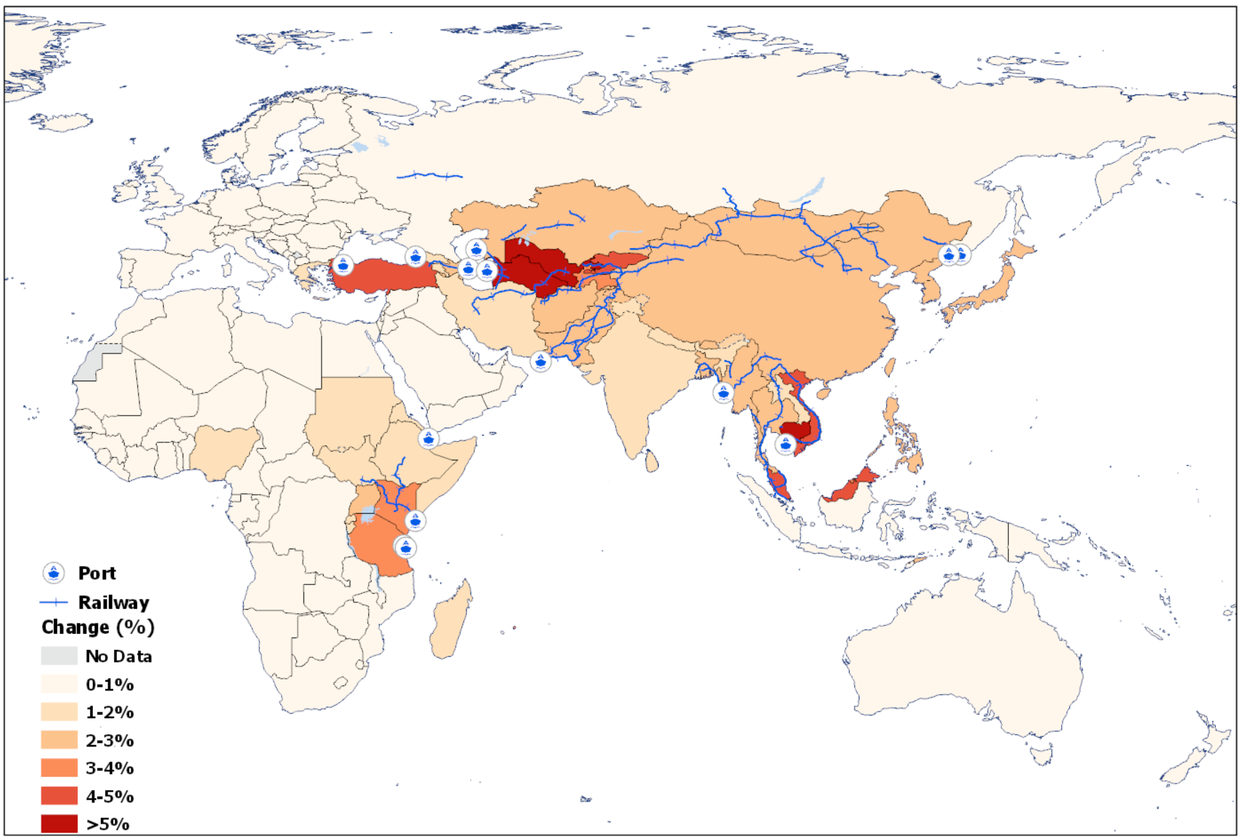
	East Asia & Pacific	Europe & Central Asia	Latin America & Caribbean	Middle East & North Africa	North America	South Asia	Sub-Saharan Africa
East Asia & Pacific	**2.01**						
Europe & Central Asia	**2.70**	**1.15**					
Latin America & Caribbean	**0.71**	**0.75**	**0.00**				
Middle East & North Africa	**2.99**	**0.38**	**0.05**	**0.14**			
North America	**1.06**	**0.74**	**0.00**	**0.18**	**0.00**		
South Asia	**4.67**	**0.88**	**1.15**	**0.70**	**1.49**	**3.59**	
Sub-Saharan Africa	**2.54**	**1.06**	**0.55**	**0.91**	**0.47**	**2.59**	**0.97**

Note: Results are from the Lower Bound analysis and averaged over all country-pairs in each region-pair.

[13] Regions are defined using the World Bank classification.

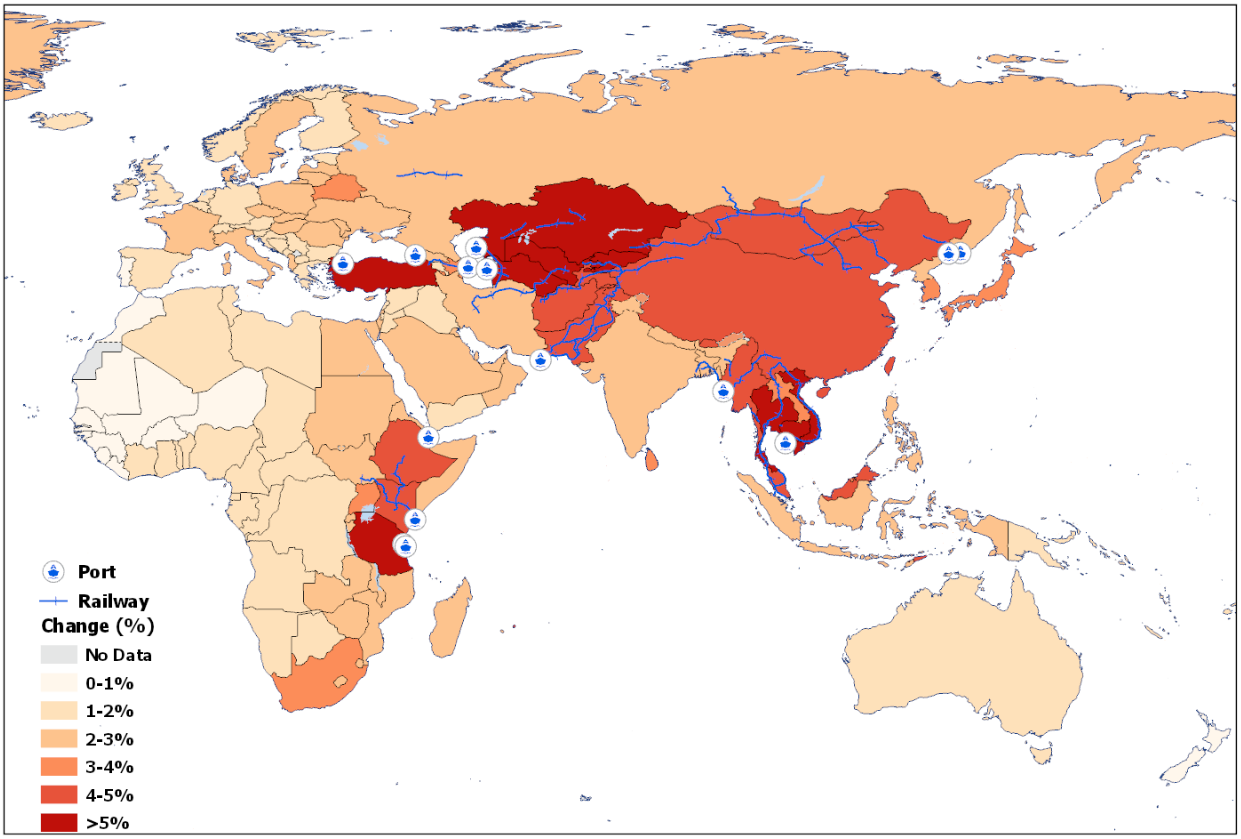
Another interesting feature that naturally comes out of our network approach is the global and systemic impact of localized infrastructure projects. Upon the implementation of a new/upgraded port or rail, shipping time decreases for all routes going through the new network element. This means, for example, that the BRI will also reduce shipping times – and ultimately trade costs – not only between BRI countries, but also potentially between country-pairs that are not part of the Initiative. For instance, Tanzania's Bagamoyo port is expected to benefit not only Tanzania but several other countries in the region. As a result, when all BRI transport projects are implemented, our analysis shows that shipping time between Australia and Rwanda is expected to decrease by 0.5 percent. Similarly, the improvement of Djibouti's port will contribute to a decrease in shipping time between Australia and Ethiopia of 1.2 percent.

Figure 4: Average decrease of shipping time per country – Lower Bound.



Note: For each country, the aggregate proportional decrease is computed as the average of proportional shipping time decrease with all other countries in the world.

Figure 5: Average decrease of shipping time per country – Upper Bound.



Note: For each country, the aggregate proportional decrease is computed as the average of proportional shipping time decrease with all other countries in the world

In general, the results highlight the systemic impact of the transport projects in reducing shipping times. While some country-pairs are not expected to experience changes in shipping time, the benefits from all those investments will spread far beyond the countries formally participating in the initiative. Hence, only a holistic network approach, taking into account the details of both the current network of infrastructure and the planned projects, can account for all interconnections and spillover effects that can be expected from the BRI.

As a last exercise, we look at how much BRI-related transport projects would reduce shipment times along the economic corridors identified as part of the Initiative.[14] Perhaps not surprisingly, we find that reductions in shipment times are larger, and in some cases much larger, along the economic corridors. The smallest improvements in travel times are for the China-Mongolia-Russia Economic Corridor (CMREC) for which the simple average decrease in shipping time is 3.6 percent (for the lower bound) and 3.8 percent (for the upper bound). The largest improvements are for the China-Central Asia-West Asia Economic Corridor (CCWAEC): the simple average decrease in shipping times between CCWAEC countries is 10.3 percent (for the lower bound) and 11.9 percent (for the upper bound). As we show in Section 5, the impact of the BRI on travel times along the corridors would be further magnified by the

[14] See Annex Table A.1 for the details of projects by corridors.

implementation of complementary reforms aimed at reducing border delays and improving the management of corridors.

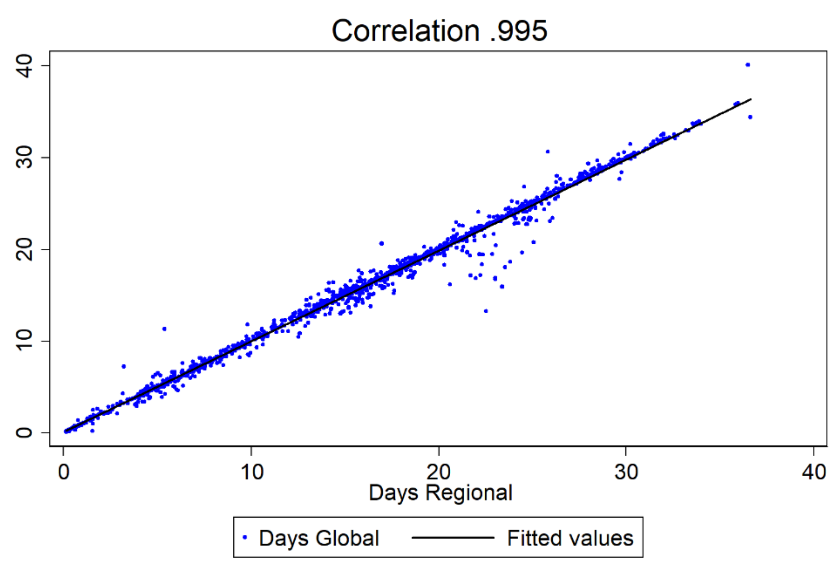
The main conclusions from the analysis on the impact of the BRI on shipping times across countries based on the global database are also valid for the regional database. Specifically, the proportional decrease in shipping times after the BRI interventions within the BRI region for the lower and upper bound scenarios is equal to 2.86 percent and 4.45 percent on average for the regional database, compared to 2.37 percent and 3.96 percent for the global database (see Table 7).

Table 7: Improvements in shipment times post-BRI, comparative statistics for regional and global databases on BRI sub-sample of countries.

	Min		Max		Mean		Std.Dev.	
	Regional	Global	Regional	Global	Regional	Global	Regional	Global
% decrease in trading times – Lower Bound	0.00	0.00	79.29	61.52	2.86	2.37	4.93	4.30
% decrease in trading times – Upper Bound	0.00	0.00	79.29	65.16	4.45	3.96	6.03	5.42

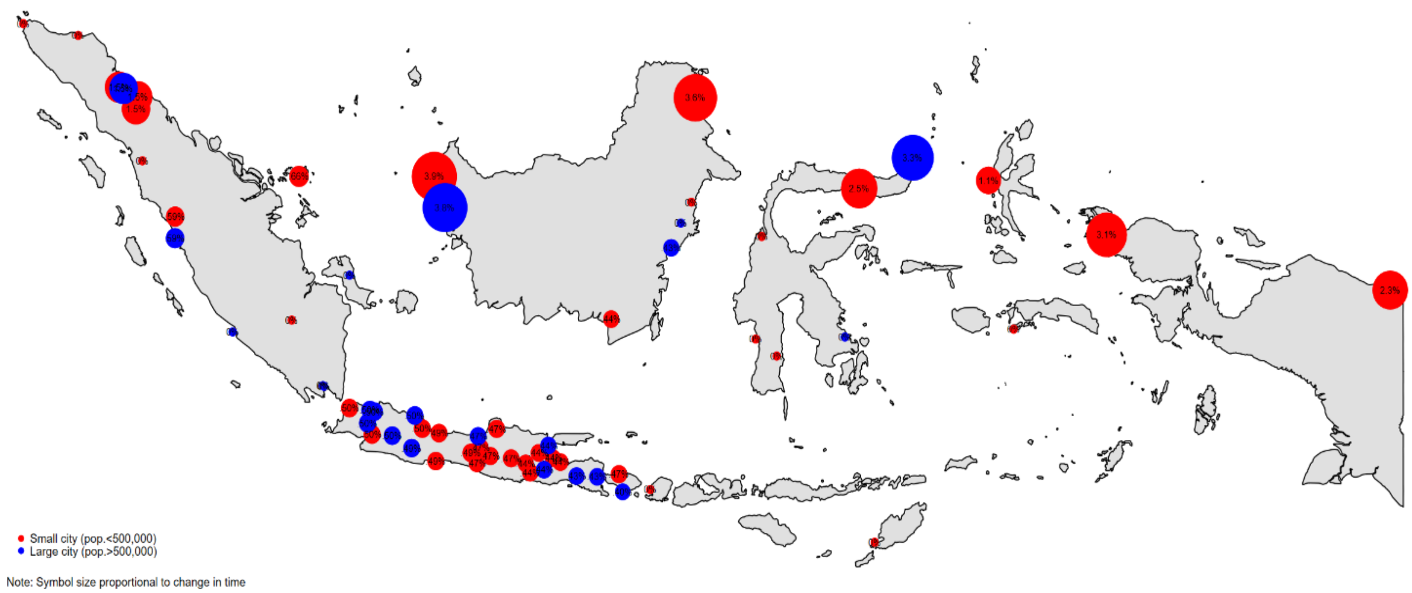
Figure *6* plots shipment times across country pairs for the global and regional databases. Most of the points are around the 45-degree line suggesting that the average time it takes to connect two countries is very similar. The correlation between country-pair shipping times in the global and regional databases pre-BRI and post-BRI are equal to 0.995. The high similarity in trading times at the country-pair level between the regional and global data sets is not surprising given that the shipping times across cities are aggregated using population as weights.

Figure 6: Correlation between global and regional databases shipping times at the country-pair level



Differences between the regional and the global data sets might arise when distances and shipping times are computed within countries. In other words, the additional granularity that the regional data set provides would allow to assess whether small and more isolated cities would gain from the BRI. The case of Indonesia is an interesting example to illustrate this. Figure 7 highlights the improvements in shipping times post BRI for small cities – cities with population less than 500,000 inhabitants (red dots) and big cities – cities with population greater than 500,000 inhabitants (blue-dots). The size of the dots in the figure is proportional to the average decrease in trading times that a certain city would experience with the rest of the BRI region. The BRI has a positive impact to trading times not only on bigger cities that are usually more connected to the network but also on smaller cities that might be located in the periphery of a country. Papers exploiting the granularity of the regional database include Bird et al. (2018).

Figure 7: Impact of BRI improvements for Indonesian cities.



4. Effects of the Belt and Road Initiative on trade costs

Trade barriers between two countries can take many different forms, including tariffs, quotas and various forms of non-tariff measures such as import licensing or technical standards. Shipment time can also be a form of trade barrier. As customers and firms value accessing goods in a timely manner, any delay in serving different markets might result in a reduction of associated trade flows. Hence, reducing the time it takes to ship and process goods between two countries, either through improvement in infrastructure and shipping routes or through an increase in the efficiency of the clearing process at the border, is likely to reduce trade costs and positively impact the quantity being actually traded.

In this section, we study how the changes in shipment times associated to the Belt and Road Initiative that we have identified in Section 3 translate in changes in trade costs. The analysis will be applied to the global database only, as the main results are valid when considering trading times across countries from the regional database.

A difficulty in this exercise is that the sensitivity of trade flows to shipment time strongly depends on the characteristics of the product considered. In other words, the "value of time" is not equal across industries. Among many sector-specific characteristics governing the impact of time on trade, one can cite the rate of depreciation, storability, seasonality, demand uncertainty or substitutability with domestic products. All those traits influence the elasticity of shipment time to trade flows and it is important to take into account this heterogeneity across sectors.

In the rest of the section, we first discuss the methodology used to transform shipment times into trade costs, then we present the results for the global and regional databases.

a. From shipment times to trade costs

To transform the shipment times from our network analysis into trade costs, we use the seminal work of Hummels and Schaur (2013). This paper provides estimates for the ad-valorem value of a shipment day for many sectors, at both four-digit and two-digit levels of disaggregation in the Harmonized System (HS). Recognizing the fact that air cargo is many times more expensive than maritime transport but arrives in destination markets much faster, Hummels and Schaur (2013) use U.S. imports data and detailed information on the premium paid for air shipping and in time lags for ocean transit to identify consumers' valuation of time. To our knowledge, these results constitute the most comprehensive and detailed estimates of value of time at the sectoral level, providing rich heterogeneity and overcoming several endogeneity issues faced by previous work.

An obvious limitation of these estimates is that they are based on information from the United States, which might create at least two types of potential biases when using the values for a worldwide analysis. First, there may be a selection issue since the United States does not have positive imports in every sector, which means that we must rely on averages for some sectors. Second, the value of time may be to some extent country-specific. Consumers in different countries could be characterized by different valuation of delivery time, because of different taste or different ability to store goods. Below, we discuss extensively in this section how we deal with the first problem. The second problem cannot be easily solved due to lack of data. It is a caveat to bear in mind, although the direction of the bias is difficult to assess ex ante.

In order to construct new data for the ad-valorem "value of time" in GTAP, we must aggregate the estimates at HS-levels from Hummels and Schaur (2013) into GTAP sectors. To perform such aggregation, it must be noted that GTAP sectors are aggregates of many HS categories which are represented with different weights for different country-pairs. As a result, a given GTAP sector should not necessarily be associated with the same "value of time" when we consider different origin and destination countries. To make things clear, let us describe the following simplistic example. A GTAP sector named GTAP_1 is made of three HS categories HS_1 HS_2 and HS_3. The associated "value of time" raw estimates for the HS categories are τ^{HS1}, τ^{HS2} and τ^{HS3} respectively.

Looking at the trade flows between two countries (Country 1 and Country 2) for the GTAP sector GTAP_1, we observe that the composition of GTAP_1 is not the same when country 1 is exporting or importing:

Table 8: Disaggregated trade flows between country 1 and country2 in sector GTAP_1

Origin	Destination	GTAP Sector	HS Category	T	Trade Flow
Country 1	Country 2	GTAP_1	HS_1	τ^{HS1}	5
Country 1	Country 2	GTAP_1	HS_2	τ^{HS2}	20
Country 1	Country 2	GTAP_1	HS_3	τ^{HS3}	10
Country 2	Country 1	GTAP_1	HS_1	τ^{HS1}	30
Country 2	Country 1	GTAP_1	HS_2	τ^{HS2}	10
Country 2	Country 1	GTAP_1	HS_3	τ^{HS3}	5

For each directed pair of countries, we then build the "value of time" associated with the trade of GTAP_1 from the origin to the destination, by taking the trade-weighted average of the underlying HS estimates from Hummels and Schaur (2013). Using the numerical example above, the value from country 1 to country 2 and from country 2 to country 1 are then computed as:

$$\tau_{1\rightarrow 2}^{GTAP1} = \frac{5}{35} \times \tau^{HS1} + \frac{20}{35} \times \tau^{HS2} + \frac{10}{35} \times \tau^{HS3}$$

$$\tau_{2\rightarrow 1}^{GTAP1} = \frac{30}{45} \times \tau^{HS1} + \frac{10}{45} \times \tau^{HS2} + \frac{5}{45} \times \tau^{HS3}$$

To build the appropriate trade-related weights, we use UN Comtrade data on trade flows which we aggregate at the 4-digit or 2-digit levels to construct sector and origin-destination specific weights for the aggregation.[15]

One particular issue when building the aggregation is the treatment of missing values. While Hummels and Schaur (2013) provides "value of time" estimates for many sectors at either HS2 or HS4 levels, the data also contains many missing observations. Since the US imports only a subset of all HS categories, it is not surprising that data are missing for many HS categories. As discussed in Minor and Hummels (2013), the treatment of those missing values is an important component of the aggregated results.

One solution could simply be to discard, in the aggregation, HS sectors for which we do not have estimates of the value of time. Doing so yields the possible issue that GTAP aggregated values might be computed based on an arbitrarily small fraction of actual trade flows. This, in turn, can then bias aggregated values if the only HS4 sectors for which we have non-missing data for the cost of time feature an abnormally high

[15] Regarding which level of aggregation is the most useful in our case, our preference goes with the HS2 level estimates. HS4 level results present the advantage to cover more disaggregated sectors which can be important in some applications, the associated estimates are more likely suffer from a low number of observation which makes the results more sensitive to measurement errors and outliers. Estimates at the HS2 levels pool together sectors that might not be homogenous, but are based on a higher number of observations within each category and, hence, feature more realistic values.

(or low) value. If those sectors represent only a small fraction of total trade flows, it would be misleading to impose an extreme value of time costs to all HS4 categories within the given GTAP sector.

We take a different approach to deal with the missing values. Specifically, we follow Minor and Hummels (2013) and replace missing values at the HS4 level by the average of non-missing ones within any given GTAP sector. Doing so enables us to use trade flows of all HS4 / HS2 categories in the construction of weights. We clarify our procedure with the numerical example developed above. Consider the case where Hummels and Schaur (2013) were not able to estimate τ^{HS3}, for example because the U.S. data do not feature any import of this category. In such a case, we create an average value $\overline{\tau^{HS3}}$ computed as the average "value of time" of all non-missing HS categories within the GTAP sector. If the world consists of only our two countries 1 and 2, the formula for $\overline{\tau^{HS3}}$ would be simply:

$$\overline{\tau^{HS3}} = \frac{35}{65} \times \tau^{HS1} + \frac{30}{65} \times \tau^{HS2}$$

We then replace missing values in our data set with those averages and obtain:

Table 9: Disaggregated trade flows between country 1 and country2 in sector GTAP_1

Origin	Destination	GTAP Sector	HS Category	T	Trade Flow
Country 1	Country 2	GTAP_1	HS_1	τ^{HS1}	5
Country 1	Country 2	GTAP_1	HS_2	τ^{HS2}	20
Country 1	Country 2	GTAP_1	HS_3	$\overline{\tau^{HS3}}$	10
Country 2	Country 1	GTAP_1	HS_1	τ^{HS1}	30
Country 2	Country 1	GTAP_1	HS_2	τ^{HS2}	10
Country 2	Country 1	GTAP_1	HS_3	$\overline{\tau^{HS3}}$	5

Using this procedure enables us to create "value of time" for each GTAP sector and origin-destination pairs that contain at least one HS category that is traded. Of course, country pairs that do not trade at all a given GTAP sector cannot be associated with any "value of time". We then build the ad-valorem time barrier by simply multiplying the shipment time (computed using the network analysis described in Section 3) and the value of time aggregated from HS2 estimates derived above. It is important to keep in mind that for a given shipment time, the ad-valorem time barriers feature sectoral heterogeneity: some sectors are highly time sensitive (for example perishable products) while others are not. Table 10 presents the percentage decrease in total trade barrier, as a percentage change from the initial value.

Table 10: Percentage decrease in total time-trade barriers due to the BRI

	Min	Max	Mean	Std Dev
	World			
% decrease in time-trade barrier – Lower Bound	0.0%	61.52%	1.19%	2.63%
% decrease in time-trade barrier – Upper Bound	0.0%	65.16%	2.49%	3.66%
	BRI Countries			
% decrease in time-trade barrier – Lower Bound	0.0%	61.52%	1.74%	3.34%
% decrease in time-trade barrier – Upper Bound	0.0%	65.16%	3.24%	4.51%

Note that time-trade barrier is the product of shipping time and the value of time from Hummels and Schaur (2013) aggregated into GTAP sectors.

The last step is to calculate the total trade costs. Overall, the time barrier associated with the shipment between two cities is only a fraction of trade costs, which also contains the actual transportation cost as well as the tariffs and other monetary charges that can be applied between respective countries. In the previous section, we focused our analysis on the decrease in trade barriers that can be achieved from a reduction in shipping time and estimated associated decrease in ad-valorem costs. We now need to account for the fact that trade costs encompassing these other elements. In particular, we assume that total trade costs are defined as follows:

Trade Cost = tariff + transport + time cost

Assuming that both tariff and transportation costs are unchanged, we now compute the decrease in total trade costs that can be expected from the sheer decrease in shipping time and the value of time computed above.

We use data from the latest release of the GTAP database, version 10. One of the main advantages of the GTAP database is the ability to use data related to both tariffs and transport costs at the sectoral level. The complete database contains a total of 57 sectors. In our analysis, we focus on the 47 good sectors and do not consider the remaining 10 service sectors as the value of time and the economic determinants of trade costs for services are very different and outside of the scope of this paper. Moreover, the complete data set also contains information on other macroeconomic variables such as input-output matrices or sectoral employment and sales, which can be very useful when using our estimates in the context of a lager general equilibrium model that needs to be calibrated.

One of the caveats of using GTAP, however, is the geographical aggregation is less precise than our previous shipping time analysis. The data contain a total of 140 "regions" and an aggregated rest of the world. While this aggregation means that we are decreasing the geographical granularity of our results, it enables us to build trade costs estimates in a consistent way for a large number of countries and sectors.

b. Results

We now present the key results of the impact of BRI related transport projects on trade costs based on the global database. Compared to the figures presented in Section 3, which related to changes in shipping time only, the results presented in this section feature two main differences. First, because trade barriers are not only composed of the time element but also the actual logistical costs and tariffs which we assumed to be unaffected by the BRI, the decrease in trade costs are lower than the decrease in shipping time. Second, while results presented in Section 3 were inherently symmetric across country-pairs, the reductions in trade costs are *not* symmetric. This is due to the differences in the basket of goods traded within country pairs. If, for example, country A exports mostly time sensitive goods to country B, but imports only time insensitive goods, then a reduction in shipping times will induce a larger decrease in export costs than in import costs for country A and vice versa for country B.

Table 11 gives a first overview of our results for both our lower bound and upper bound scenarios. The decrease in trade costs associated with the BRI features a lot of geographical and sectoral heterogeneity. On average, the decline in trade costs associated to BRI projects ranges between 1.05 and 2.19 percent. For some country-pairs this decline is zero, while the maximum change ranges between 61.52 and 65.16 percent.

Table 11: Percentage decrease in trade costs due to the BRI

	Min	Max	Mean	Std Dev
	World			
% decrease in trade cost – Lower Bound	0.0%	61.52%	1.05%	2.43%
% decrease in trade cost – Upper Bound	0.0%	65.16%	2.19%	3.40%
	BRI Countries			
% decrease in trade cost – Lower Bound	0.0%	61.52%	1.50%	3.07%
% decrease in trade cost – Upper Bound	0.0%	65.16%	2.81%	4.18%

Note: Summary statistics across all country-pairs and sectors in the world.

Table 12 presents the non-symmetric matrix of trade cost changes by region-pair. The results display a similar pattern to the one previously discussed for the shipping time: East Asia and Pacific has the largest gains, followed by South Asia. Some pairs of regions experience no or small changes in trade costs, but all regions have significant gains with at least one of their trading partners. The systemic nature of the Belt and Road Initiative is apparent from the results. First, gains are not limited to the BRI economies or to country-pairs involving at least one BRI economy. For example, averaging across sectors, the decrease in trade costs between Australia and Kirghizstan amounts to 11.1 percent, among the top 2 percent of all country-pair gains. Trade costs between these two countries are expected to decrease from the BRI especially from the new railways and ports in Pakistan.

Second, the largest decrease in trade costs are not captured by the countries with the largest amount of transport projects. With more than 2,500km of new rail and more than 1,000km or upgraded rail, Mongolia is among the countries with the highest investment. When computing the proportional decrease in trade costs with all its partners weighted by import flows (which could be interpreted as the average decrease in import costs for the country), Mongolia experiences a decrease of only 3.22 percent. The same computation for Kenya reveals a decrease in import cost of more than 4.65 percent even though the country is expected to build 1,800km of new rail and a new port.

Table 12: Proportional decrease in trade costs, aggregated by regions.

	East Asia & Pacific	Europe & Central Asia	Latin America & Caribbean	Middle East & North Africa	North America	South Asia	Sub-Saharan Africa
East Asia & Pacific	**1.46**	**2.42**	**0.64**	**2.50**	**0.96**	**3.55**	**2.19**
Europe & Central Asia	**2.39**	**0.91**	**0.72**	**0.32**	**0.70**	**0.74**	**0.95**
Latin America & Caribbean	**0.65**	**0.71**	**0.00**	**0.04**	**0.00**	**1.08**	**0.51**
Middle East & North Africa	**2.69**	**0.31**	**0.04**	**0.11**	**0.17**	**0.56**	**0.79**
North America	**0.99**	**0.66**	**0.00**	**0.15**	**0.00**	**1.21**	**0.41**
South Asia	**3.84**	**0.81**	**1.06**	**0.57**	**1.32**	**3.17**	**2.30**
Sub-Saharan Africa	**2.40**	**1.03**	**0.53**	**0.85**	**0.45**	**2.44**	**0.86**

Note: Results are from the Lower Bound analysis and averaged over all country-pairs in each region-pair.

The unit of observation in our results is at the origin-destination-sector level.[16] We aggregate the observation for each country to provide an overview of the results. Naturally, there are different ways to aggregate the results at the country level. For example, trade costs are expected to decrease by 6.1 percent between Cambodia and Denmark, which is very significant. But what is the meaning of such a decrease for a firm in Cambodia that does not source any input from Denmark and/or does not sell any good to Denmark? One possible aggregation scheme consists of weighting all destinations by import or export flows and hence gain some insight regarding the potential gain for a global buyer or seller in each country. Figure 8 and *Figure 9* present such an aggregation and show the gains weighted by import flows, so that the results can be interpreted through the lenses of a firm that sources its inputs from abroad.

An important caveat to bear in mind is that aggregating all destinations using *current* trade flows (either imports or exports) as weights might give a biased view of the results. Indeed, current trade weights only provide a static view of the world and do not account for the dynamic impact of the BRI. By reducing trade costs differentially across all country pairs, the BRI will trigger a reallocation of comparative advantages across countries in a complex way and it will change the share of every trading partner in each country's aggregate imports and exports basket. While assessing those effects is beyond the scope of this paper,[17] Table 13 shows how different aggregations impact the way one can interpret the results. Both the ranking and the magnitude of the gains are strongly affected by the way the results are aggregated.

[16] The database contains a variety of useful information and input for researchers such as ad-valorem equivalents of a shipment day at the sector level.

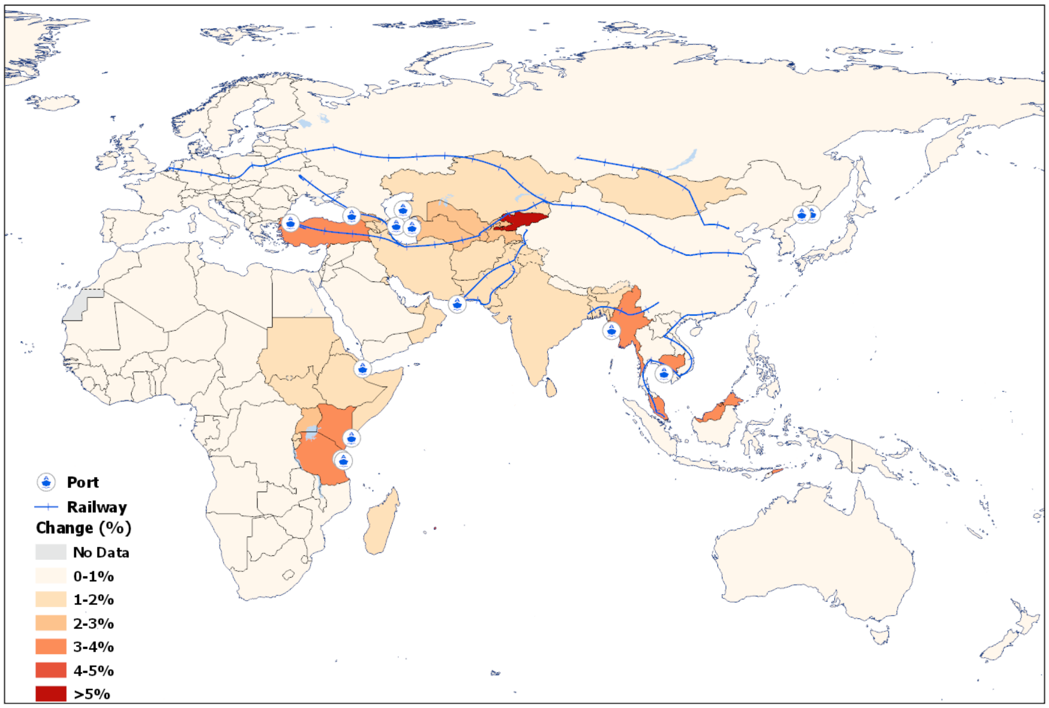
[17] Several papers use our data set as input to give predictions regarding changes in trade flows, GDP, FDI or welfare using a variety of methods. See for example de Soyres, Mulabdic and Ruta (2018), Baniya, Rocha and Ruta (2018), Maliszewska, van der Mensbrugghe and Osorio-Rodarte (2018), Chen (2018) or Bird, Lebrand and Venables (2018).

Table 13: Ranking of countries according to the proportional decrease of its trade costs – based on lower bound scenario.

	Import weights		Export weights		No weights	
Rank	Country	Gains (%)	Country	Gains (%)	Country	Gains (%)
1	Cambodia	9.30	Kyrgyzstan	6.01	Rest of Former USSR	6.78
2	Tajikistan	5.60	Tajikistan	4.54	Cambodia	5.65
3	Kenya	4.65	Malaysia	4.53	Tajikistan	5.31
4	Rest of Southeast Asia	4.59	Mauritius	4.25	Kyrgyzstan	4.06
5	Tanzania	4.54	Cambodia	4.12	Mauritius	3.71
6	Rest of Former USSR	4.37	Turkey	4.02	Brunei Darussalam	3.66
7	Azerbaijan	4.34	Pakistan	3.75	Malaysia	3.61
8	Uganda	4.20	Brunei Darussalam	3.68	Vietnam	3.60
9	Turkey	4.00	Mongolia	3.60	Tanzania	3.45
10	Malaysia	3.97	Tanzania	3.59	Turkey	3.16
11	Bangladesh	3.91	Bangladesh	3.37	Kenya	3.02
12	Brunei Darussalam	3.69	Rest of Southeast Asia	3.18	Rest of South Asia	2.64
13	Taiwan, China	3.26	Rest of South Asia	3.01	Uganda	2.58
14	Mongolia	3.22	Uganda	2.99	Hong Kong SAR, China	2.46
15	Japan	3.08	Vietnam	2.85	China	2.44
16	Republic of Korea	2.97	Iran Islamic Republic of	2.72	Taiwan, China	2.42
17	Mauritius	2.75	Qatar	2.63	Rest of Southeast Asia	2.35
18	Iran Islamic Republic of	2.74	United Arab Emirates	2.59	Thailand	2.34
19	Lao PDR	2.56	Kazakhstan	2.43	Rest of East Asia	2.31
20	Rwanda	2.43	Azerbaijan	2.31	Japan	2.31

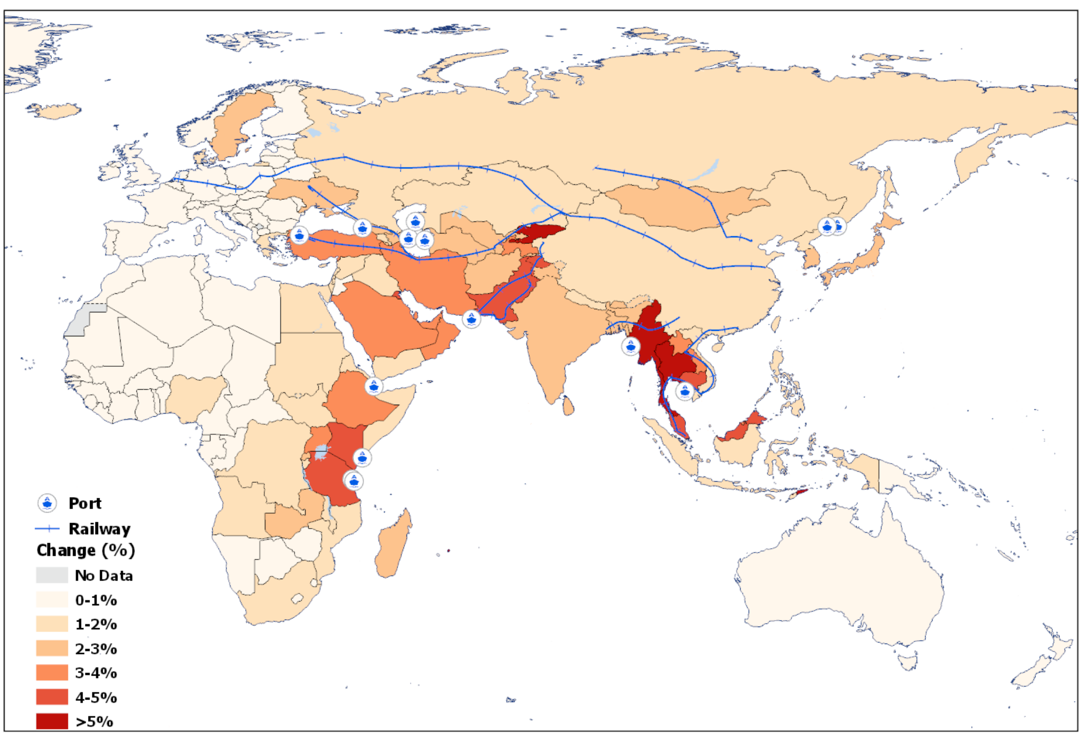
Note: "Rest of Central Asia" contains Turkmenistan and Uzbekistan. "Rest of South Asia" contains Afghanistan, Bhutan and Maldives. "Rest of South East Asia" contains Myanmar and Timor-Leste. "Rest of Eastern Africa" contains Burundi, Comoros, Djibouti, Eritrea, Mayotte, Seychelles, Somalia and Sudan. "Rest of East Asia" contains the Democratic People's Republic of Korea and China's Special Administrative Region of Macao.

Figure 8: Average decrease of trade costs per country – Lower Bound.



Note: For each country, all destinations are weighted by import flows.

Figure 9: Average decrease of trade costs per country – Upper Bound.



Note: For each country, all destinations are weighted by import flows.

Finally, we calculate how much trade costs fall along BRI economic corridors. We find that trade costs would fall by 2.4 percent for the China-Mongolia-Russia Economic Corridor (CMREC) and up to 10.2 percent for the China-Central Asia- West Asia Economic Corridor (CCWAEC) in the upper-bound scenario. All other corridors would fall somewhere in between these two extremes. An important caveat to bear in mind in reading these results is the importance of network effects. Our method, based on a shortest path algorithm on the network of transportation links allows us to take into account all possible interactions between new/upgraded transport projects; and as a result we cannot link the decrease in trade costs of one country to a simple project or even a simple corridor. While these effects are largest along corridors because of the geography of the infrastructure projects, the decreases in shipping time and in trade costs between any two countries depend potentially on the whole set of improvements. More precisely, the gains are not only impacted by the transport projects located in each of those countries, but also by the projects in all countries that are along the shortest path between the origin and destination countries.

5. Extensions and complementary policies

As we have seen in previous sections, transport infrastructures are key elements of the logistic chain and improvement in the transport network can have a significant impact on shipping time and trade costs between countries. However, by focusing only on planned transport projects related to the BRI, we might miss other gains that could be achieved through the BRI. In this section, we now turn to other policies that can affect shipping times over and beyond the improvement of the physical transport infrastructure and focus in particular on two elements: the implementation of trade facilitation policies (proxied by a reduction in the border processing time) and the improvement of corridor management and decrease in congestion (proxied by an speed increase all along economic corridors).

a. Trade facilitation

BRI economies are very heterogenous in terms of their customs policies. Bartley Johns et al. (2018) finds that the trade facilitation performance is below average along BRI corridors. One reason is that the World Trade Organization Trade Facilitation Agreement (WTO-TFA) – a multilaterally-agreed set of sound trade facilitation practices – has not been ratified by 5 BRI WTO members and does not apply to further 13 BRI economies that are not WTO members. In this section, we investigate the combined effect of implementing the trade facilitation reforms and improving the transport infrastructure on shipment time and trade cost. In particular, we analyze additional scenarios using GIS network analysis in which import and export border delays for BRI countries are reduced by 50 percent.[18] This assumption allows us to understand the potential gains from additional complementary policies.

Table 14: Trade facilitation scenario, border delays (hours).

	East Asia & Pacific	Europe & Central Asia	Latin America & Caribbean	Middle East & North Africa	North America	South Asia	Sub-Saharan Africa
	average time to trade (hours)						
Border Delay	126.96	75.50	122.40	156.87	67.51	166.56	175.47
Reduced Border Delay	95.61	57.82	109.77	111.32	55.25	102.19	159.43

[18] Data on border compliance are from the World Bank's Doing Business 2018 report.

	% decrease in time-trade Lower Bound						
Baseline	2.31	1.17	0.50	0.77	0.56	1.90	1.19
Baseline with reduced border delays	3.96	3.60	1.14	2.80	1.34	6.83	2.99
	% decrease in time-trade Upper Bound						
Baseline	3.53	2.54	1.92	2.10	2.91	3.44	2.17
Baseline with reduced border delays	5.89	6.04	2.94	6.53	3.94	9.77	4.17
	% decrease in trade cost Lower Bound						
Baseline	1.96	1.01	0.47	0.67	0.50	1.66	1.13
Baseline with reduced border delays	3.43	3.08	1.08	2.46	1.21	6.22	2.86
	% decrease in trade cost Upper Bound						
Baseline	2.95	2.18	1.77	1.84	2.48	2.96	2.05
Baseline with reduced border delays	5.01	5.14	2.74	5.81	3.43	8.77	3.98

Note: "Reduced border delay" assumes a 50 percent reduction in import and export delays for BRI countries. Simple average by region across all destinations.

Table 14 presents the results with reduced border delays for BRI countries. In terms of delays, all regions experience a decrease in the average time to cross borders. South Asia experiences the largest reduction in the average time to cross borders, which decreases by 64 hours from 166, followed by Middle East and North Africa. The importance of improvement in custom policies is reflected in the lower and upper bound results for trade costs and time to trade. We find that the percentage decreases in time-trade and trade costs are three times as large as those in the baseline scenarios. For instance, along BRI corridors the improvements in shipping times would range between 11 percent for the China-Pakistan Economic Corridor (CPEC) and 25.5 percent of the China-Central Asia-West Asia Economic Corridor (CCWAEC) in the upper-bound. Similarly, trade costs would fall by 10.2 percent for the China-Pakistan Economic Corridor (CPEC) and by 21.6 percent for the China-Central Asia-West Asia Economic Corridor (CCWAEC) in the upper-bound scenario. These results show that border delays represent a large component of the overall time it takes to trade and emphasize the importance of complementary policies for reaping the benefits of the BRI.

b. Corridor management

The Belt and Road Initiative is structured around two main components, (i) the Silk Road Economic Belt (SREB), and (ii) the 21st Century Maritime Silk Road (MSR). The "Belt", in turn, is organized along six economic corridors. As discussed in Kunaka (2018), along with the new and updated infrastructure, management of the transport network along these corridors may improve through a set of complementary policy actions (e.g. harmonization of technical standards, single clearance mechanism). In this section, our goal is to estimate the additional benefits in terms of shipment times and trade costs that can be achieved by improving the overall management of those economic corridors. To implement this in a practical way in our GIS analysis, we run an additional scenario in which the speed of transportation along the entire length of the corridors is increased from 50km/h to 75km/h.[19] We see this assumption as a reasonable first approximation for the improvement in flow and congestion management and the better organization of transport that can be achieved through an overall oversight of the economic corridors.

The overall additional impact of improved corridor management is small. But the impact is significant for some countries in Europe and Central Asia and East Asia and Pacific. Results in Table 15 show that improved corridor management is important for countries in the proximity of the New Eurasian Land Bridge and the China–Central Asia–West Asia Economic Corridors (CCWAEC) such as Kazakhstan and the Kyrgyz Republic. These two countries would gain at least one additional percentage point improvement in the average time-trade from better corridor management. The benefits from improved corridor management for countries in East Asia and Pacific are smaller as for them border delays represent a large part of the trade cost. The largest impact of improved corridor management would be felt among the countries that lie along the corridor. In the upper-bound scenario, shipping times would fall by 7 percent in the China-Mongolia-Russia Economic Corridor (CMREC) and by up to 20.4 percent for the China-Pakistan Economic Corridor (CPEC). The associated change in trade costs would range between 5.1 percent and 17 percent for the China-Mongolia-Russia Economic Corridor (CMREC) and the China-Pakistan Economic Corridor (CPEC), respectively. All other corridors would fall somewhere in between these two extremes.

Table 15: Improved corridor management scenario, increase in speed along the entire length of the corridors.

		% Change - Lower Bound				% Change - Upper Bound			
		time-trade		trade cost		time-trade		trade cost	
Country	Region	Baseline	Baseline w/ Corridor Mgmt.	Baseline	Baseline w/ Corridor Mgmt.	Baseline	Baseline w/ Corridor Mgmt.	Baseline	Baseline w/ Corridor Mgmt.
Kyrgyz Republic	Europe & Central Asia	4.09	5.24	4.08	5.23	8.26	8.62	8.24	8.60
Armenia	Europe & Central Asia	1.14	2.23	1.14	2.22	1.53	5.04	1.52	5.02
Kazakhstan	Europe & Central Asia	1.74	2.79	1.72	2.76	5.63	9.59	5.56	9.48
Mongolia	East Asia & Pacific	2.28	3.10	2.27	3.09	4.28	6.67	4.26	6.64
Russia	Europe & Central Asia	0.88	1.42	0.84	1.36	2.35	4.68	2.25	4.47
Belarus	Europe & Central Asia	0.92	1.36	0.90	1.33	3.82	6.32	3.74	6.19
Turkey	Europe & Central Asia	3.36	3.62	3.14	3.38	3.82	6.19	3.57	5.78
China	East Asia & Pacific	2.55	2.74	2.42	2.60	3.65	5.14	3.47	4.88
Thailand	East Asia & Pacific	2.46	2.60	2.34	2.47	4.21	6.02	4.01	5.72
Hong Kong SAR, China	East Asia & Pacific	2.49	2.63	2.45	2.59	2.84	4.80	2.79	4.72
Canada	North America	0.84	0.94	0.80	0.90	3.65	7.84	3.50	7.49
Honduras	Latin America & Caribbean	0.72	0.78	0.71	0.77	2.35	6.42	2.32	6.34
Jamaica	Latin America & Caribbean	0.76	0.81	0.75	0.80	2.26	5.82	2.23	5.79
Bulgaria	Europe & Central Asia	0.89	0.93	0.85	0.89	2.09	6.48	2.01	6.22
Dominican Republic	Latin America & Caribbean	0.79	0.82	0.78	0.81	2.27	5.96	2.23	5.87
Romania	Europe & Central Asia	0.93	0.96	0.90	0.93	2.55	6.00	2.46	5.79
Bangladesh	South Asia	1.79	1.81	1.75	1.77	2.19	7.20	2.15	7.05
Azerbaijan	Europe & Central Asia	2.15	2.16	2.13	2.14	2.93	7.41	2.91	7.34

Note: Simple average by country across all destinations (countries with largest percentage point differences)

[19] To stress the difference with the scenarios discussed in Sections 3 and 4, note that in that exercise the increase in speed is only along the segments that are either new or upgraded.

6. Conclusion

This paper studies the effects of the Belt and Road Initiative on shipment times and trade costs for countries that are along the Belt and Road as proposed by China and for the world more broadly. The analysis combines detailed new information on transport infrastructure projects planned as part of the BRI, a GIS network model to precisely quantify the impact of these projects on shipping times, and estimates of the value of time from Hummels and Schaur (2013) to calculate the ad valorem equivalent reductions in trade costs. The key finding is that the Belt and Road Initiative can substantially reduce shipment times and trade costs for BRI economies (up to 3.2 and 2.8 percent, respectively) and for the world as a whole (up to 2.5 and 2.2 percent, respectively).

The main contribution of the paper is in the new methodology used to quantify changes in trade costs due to transport projects and the two novel databases that provide detailed information on BRI-induced changes in shipment times and trade costs for the world and for BRI economies. These data, in particular, will help researchers interested in better understanding the impact of the Belt and Road Initiative on a number of economic variables, including growth, trade, foreign investment, or the allocation of economic activity. The data may also be useful to investigate the systemic effects of BRI projects on non-economic variables such as air pollution or biodiversity or on social outcomes, such as the changes in poverty for certain groups in specific geographic locations.

Admittedly, this is a first look at the effects of the BRI on shipment times and trade costs and more research will be needed. First, on the data side, information on infrastructure projects linked to the Belt and Road Initiative will change -and, most likely, improve- over time. Second, on the methodological side, research may attempt to precisely model the choice between transport modes and how this choice is affected by BRI infrastructure projects. These developments would allow to improve the network analysis and provide more precise estimates.

Finally, this paper does not address two sets of important questions. First, we take BRI planned projects as given and do not investigate what network of infrastructure would maximize efficiency (in terms of reduction of shipment times and trade costs) for the set of BRI economies or the world. Second, we look at the impact of the infrastructure projects linked to the Belt and Road Initiative as a whole and do not attempt to identify the effects on shipment times and trade costs for, say, individual overland corridors such as the China Pakistan Economic Corridor (CPEC) or individual projects, such as the Gwadar Port. While the tools developed in this paper would help address these issues, both questions are left for future research.

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Annex 1: List of BRI economies used in this study

No.	Economy	WBG Region	Included in 6 key BRI Economic Corridors
1	Kenya	AFR	
2	Tanzania	AFR	
3	Brunei Darussalam	EAP	
4	Cambodia	EAP	Yes
5	China	EAP	Yes
6	Hong Kong SAR, China	EAP	
7	Indonesia	EAP	
8	Lao PDR	EAP	Yes
9	Malaysia	EAP	Yes
10	Mongolia	EAP	Yes
11	Myanmar	EAP	Yes
12	Philippines	EAP	
13	Singapore	EAP	Yes
14	Taiwan, China	EAP	
15	Thailand	EAP	Yes
16	Timor-Leste	EAP	
17	Vietnam	EAP	
18	Albania	ECA	
19	Armenia	ECA	
20	Azerbaijan	ECA	Yes
21	Belarus	ECA	Yes
22	Bosnia and Herzegovina	ECA	
23	Bulgaria	ECA	
24	Croatia	ECA	
25	Czech Republic	ECA	Yes
26	Estonia	ECA	
27	Georgia	ECA	Yes
28	Greece	ECA	
29	Hungary	ECA	
30	Kazakhstan	ECA	Yes
31	Kyrgyz Republic	ECA	Yes
32	Latvia	ECA	
33	Lithuania	ECA	
34	Macedonia, FYR	ECA	
35	Moldova	ECA	
36	Montenegro	ECA	

37	Poland	ECA	Yes
38	Romania	ECA	
39	Russian Federation	ECA	Yes
40	Serbia	ECA	
41	Slovak Republic	ECA	
42	Slovenia	ECA	
43	Tajikistan	ECA	Yes
44	Turkey	ECA	Yes
45	Turkmenistan	ECA	Yes
46	Ukraine	ECA	
47	Uzbekistan	ECA	Yes
48	Bahrain	MENA	
49	Djibouti	MENA	
50	Egypt, Arab Rep.	MENA	
51	Iran, Islamic Rep.	MENA	Yes
52	Iraq	MENA	
53	Israel	MENA	
54	Jordan	MENA	
55	Kuwait	MENA	
56	Lebanon	MENA	
57	Oman	MENA	
58	Palestine	MENA	
59	Qatar	MENA	
60	Saudi Arabia	MENA	
61	Syrian Arab Republic	MENA	
62	United Arab Emirates	MENA	
63	Yemen, Rep.	MENA	
64	Afghanistan	SAR	Yes
65	Bangladesh	SAR	Yes
66	Bhutan	SAR	
67	India	SAR	Yes
68	Maldives	SAR	
69	Nepal	SAR	
70	Pakistan	SAR	Yes
71	Sri Lanka	SAR	

Annex 2: List of BRI transport projects

The set of projects included in our network analysis is largely drawn from the list compiled and presented in Reed and Trubetskoy (2018). In our analysis, we retained most of the projects related to rail and ports from this source, with a few additional projects (indicated by asterisk), as reflected in the list below.

Table A. 1: Projects of the Silk Road Economic Belt included in the network analysis

Corridor	Type of Infrastructure	Project	Countries
CHINA-MONGOLIA-RUSSIA ECONOMIC CORRIDOR (CMREC)	rail	Central Rail Corridor	China, Mongolia, Russian Federation
	rail	*China rail Zhangjiakou - Datong	China
	rail	Northern Rail Corridor	Mongolia, Russian Federation
	rail	Western Rail Corridor	China, Mongolia
	rail	Eastern Rail Corridor	China, Mongolia
	rail	Seaside I Corridor	China, Russian Federation
	port link	Vostochny port	Russian Federation
	rail	Seaside II Corridor	China, Russian Federation, Mongolia
	port link	Zarubino	Russian Federation
	rail	Southern Coal Railway	China, Mongolia
NEW EURASIAN LAND BRIDGE (NELB)	rail	Khorgos-Aktau Railway	Kazakhstan
	port link	Aqtau port	Kazakhstan
	rail	Moscow-Kazan HSR	Russian Federation
	rail	Urumqi-Khorgos	China, Kazakhstan
	rail	*Arkalyk-Shubarkol	Kazakhstan
	rail	*Marmaray rail tunnel	Turkey
	rail	*North-South Connector (Gorgen - Uzen)	Iran, Islamic Republic of, Kazakhstan, Turkmenistan
CHINA-CENTRAL ASIA-WEST ASIA ECONOMIC CORRIDOR (CCWAEC)	rail	Tehran-Mashad rail	Iran, Islamic Republic of
	rail	Tehran-Isfahan HSR	Iran, Islamic Republic of
	rail	Kashgar-Tashkent rail	China, Kyrgyzstan, Uzbekistan
	rail	Sher Khan-Herat rail	Afghanistan
	rail	*Sher Khan-Herat rail extension to Termiz	Afghanistan, Uzbekistan
	rail	Samarkand-Mashad rail	Iran, Islamic Republic of, Turkmenistan, Uzbekistan
	rail	Kashgar-Dushanbe rail	China, Kyrgyzstan, Tajikistan
	rail	Dushanbe-Afghan	Afghanistan, Tajikistan
	port link	Baku port	Azerbaijan
	sea route	Caspian Sea link Baku-Aqtau	
	sea route	Caspian Sea link Baku-Turkmenbashi	
	port link	Turkmenbashi port	Turkmenistan
	rail	*Turkmenbashi port rail	Turkmenistan
	rail	Baku-Tbilisi rail	Azerbaijan, Georgia

Corridor	Type of Infrastructure	Project	Countries
	rail	Tbilisi-Kars rail	Georgia, Turkey
	rail	Anaklia	Georgia
	port link	Anaklia port	Georgia
	port link	Ambarli port	Turkey
CHINA-PAKISTAN ECONOMIC CORRIDOR (CPEC)	rail	China-Pakistan rail	China, Pakistan
	rail	Havelian-Hyderabad capacity expansion	Pakistan
	rail	Karachi-Peshawar capacity expansion	Pakistan
	port link	Gwadar port	Pakistan
	rail	Gwadar rail	Pakistan
	rail	Alternative Gwadar rail passage	Pakistan
	rail	Besima-Jacobabad	Pakistan
BANGLADESH-CHINA-INDIA-MYANMAR ECONOMIC CORRIDOR (BCIM)	rail	Kunming-Calcutta high speed rail	Bangladesh, China, India, Myanmar
	rail	Dali-Lashio rail	China, Myanmar
	rail	Kalay-Jiribam rail	India, Myanmar
	rail	Dhaka-Bongaon rail	Bangladesh
	port link	Kyaukpyu port	Myanmar
CHINA-INDOCHINA PENINSULA ECONOMIC CORRIDOR (CICPEC)	rail	Kunming-Vientiane rail	China
	rail	Bangkok-Vientiane rail	Lao PDR, Thailand
	rail	Bangkok-Kuala Lumpur HSR	Malaysia, Thailand
	rail	Kuala Lumpur-Singapore HSR	Malaysia, Singapore
	rail	Vietnam National High-Speed Railway	Vietnam
	rail	Vietnam-Cambodia rail	Cambodia, Vietnam
	rail	Bankgkok-Phnom Penh rail crossing at Poipet	Cambodia, Thailand
	rail	Burma rail Nam Tok - Thanbyuzayat	Myanmar, Thailand
	port link	Sihanoukville port improvement	Cambodia
	rail	Sihanoukville port rail	Cambodia
	canal	Kra Canal	Thailand
	rail	*East Coast Rail Link	Malaysia
	rail	*Hanoi-Lao Cai rail	Vietnam
	rail	*Kunming-Hekou rail	China
	rail	*Straits of Malacca Bridge	Indonesia

Table A. 2: Projects of the Maritime Silk Road included in the network analysis

Corridor	Type of Infrastructure	Project	Countries
MARITIME SILK ROAD (additional ports)	port link	Bagamoyo port	Tanzania, United Republic of
	port link	Dar es Salaam port improvement	Tanzania, United Republic of
	port link	Djibouti port improvement	Djibouti
	port link	Lamu port	Kenya
	rail	*LAPSSET rail corridor	Ethiopia, Kenya, South Sudan

Annex 3: Additional material

a. Current modal shares in international trade

Looking at all the trade flows in the world, maritime transportation represents the overwhelming majority of shipment both in terms of volume and in value. According to the 2017 Outlook of the OECD's International Transport Forum, "*maritime shipping accounts for more than 80% in volume and 70% in value of global trade*". The difference between the volume and value shares reflects the fact that high value goods are typically shipped using faster transportation modes.

Focusing on the economies that are part of the BRI, one can have a more precise look by using the modal shares from the GTAP database. It is important to note that those shares are not taken from underlying data but are estimated and built for all countries, but they nevertheless represent an interesting view of the current situation. Overall, Table A. 3 shows that around 90% of exported value out of BRI economies is shipped using either maritime or land links.

Table A. 3: Modal shares in BRI economies – from the GTAP database

Mode	Share (based on value)
Sea	57.6%
Land	30.6%
Air	11.7%

It is possible to go further in detail for the case of China's exports where one can have access to microdata. Looking at the shares of different transportation modes for the BRI economies, Tan and Reja (2018) use Chinese customs data which they aggregate across different destination countries. Table A. 4 presents their findings and gives a very interesting picture of the situation of Chinese exports: for all destinations, Chinese exports overwhelmingly use maritime transportation, with rail transportation being a significant portion in several destinations (most notably exports toward the Russian Federation and Belarus).

Table A. 4: Modal share (based on volume) in China's exports – from Tan and Reja (2018), based on customs data

	Black Sea	Central Asia	East Europe	Russia & Belarus	South Asia	S. East Asia	South Europe	West Europe	Total
Sea	99.4%	79.9%	96.9%	60.5%	99.2%	89.2%	99.2%	97.9%	89.4%
Rail	0.0%	14.6%	1.6%	35.5%	0.0%	0.5%	0.0%	0.4%	5.7%
Road	0.3%	5.5%	0.0%	3.8%	0.6%	10.1%	0.0%	0.0%	4.4%
Air	0.3%	0.0%	1.6%	0.2%	0.2%	0.2%	0.8%	1.7%	0.5%

Overall, the picture that emerges from those numbers is that the two main transportation modes that are relevant for our analysis are maritime and rail features.

b. Construction's method for our lower bound scenario

In order to build our lower bound data set, we start with a baseline scenario with a preference for maritime in our network analysis. The transportation mode choice is based on a threshold of the ratio of shipment time using railways vs. maritime links: when the former is more than 30% of the latter, then a maritime link is preferred. Due to changes in the geometry of the network between the baseline (pre-BRI) and the improved (post-BRI) scenario, the addition of new ports and new railways, it is possible that our shortest path algorithm leads to a change in the transportation mode. Comparing the shipment time before and after the BRI when there are such changes does not make sense, and we implement the decision rule described below in order to treat those cases.

We start by running the algorithm in the baseline and improved scenario with high maritime preference and we keep track of the share of each transport mode (rail vs. maritime). We call this first step "exercise 1". From this reference point, our goal is to build an estimated shipment time post BRI where the share of maritime and rail transport within each origin-destination pair exhibits large changes compared to the scenario "pre BRII". Comparing the changes of this modal share between baseline and improved for each city-pair allows us to identify the city-pairs experiencing a change in transportation mode which needs to be treated. Three cases are possible here:

i. The shares of maritime vs. rail are similar, in the sense that the change is smaller than 5%. This covers most cases in our data set and means that we can compare the shipment time pre- and post-BRI. When this is the case, we keep the results of exercise 1 as the end results.

ii. The share of maritime increases significantly in the post-BRI scenario. In this case, the results of exercise 1 cannot be used since we cannot compare the pre- and post-BRI results. This is typically the case when, in the baseline scenario, there is a high share of rail and the improved scenario features in a switch from rail to maritime. To solve this case, we run the shortest path algorithm (baseline + improved) **without maritime preference** and call this "exercise 2". In this setup, railways being faster than maritime ways, the modal share of rail is very high in both the baseline and improved scenarios. If the results of exercise 2 exhibit constant transport mode shares, we keep this result as final.

iii. The share of maritime decreases significantly. In this case, the results of exercise 1 cannot be used again as the improved scenario results in a switch from maritime to rail. To solve this case, we run the shortest path algorithm one more time for the improved scenario **with high maritime preference**, but this time **without any increase in the speed of rail**. Call this "exercise 3". As a result, this specific version of the improved scenario features a maritime share that is mostly equal to the share observed in the baseline. If the results of exercise 3 exhibit constant transport mode share, we keep this result as final.

If there are still pathological cases where the transportation shares change between the baseline and the improved scenario, we consider that our setup does not allow us to provide sensible results for the improvement due to the BRI. When this happens, we impose that the improved scenario is equal to the baseline scenario.

c. Elasticities from Hummels and Schaur (2013)

Estimation results at the HS4 level of disaggregation

Hummels and Schaur (2013) first compute, for 652 HS4 sectors, ad-valorem equivalents of the "daily value of time" which measure the amount that consumers are willing to pay on top of the marginal cost to receive the good one day earlier. With a mean of 0.049, it means that on average a delay of one day in shipping time is associated with an ad-valorem tariff of 4.9%, which is a significant number. However, it is worth noting that the average is partially driven by some sectors with extremely high values, as reflected by the fact that the median value is significantly below the mean, at 0.9%.

Table A. 5: Summary statistics from the tau value in Hummels and Schaur (2013), computed at the HS4 level

	Observations	Min	Max	Mean	Median
Ad Valorem daily value of time	652	2.59e-5	9.456	0.0491	0.0088

Estimation results at the HS2 level of disaggregation

When using HS4 level data, one is faced with the issue that some products have a very low number of observations, making the estimation volatile and leading to extreme values in some cases. In order to mitigate this issue, Hummels and Schaur (2013) also run their estimation at the HS2 level of disaggregation, increasing the amount of data points for each category and making the inference more reliable.

The results of such an estimation yield an average per day "value of time" of 0.85% with a minimum of 0.06% and a maximum of 10.96%. While a tariff-equivalent of close to 11% for an additional day in shipment still seems very high, such a maximum value is more in line with realistic numbers for this parameter.

Table A. 6: Summary statistics from the tau value in Hummels and Schaur (2013), computed at the HS2 level

	Observations	Min	Max	Mean	Median
Ad Valorem daily value of time	71	6.23e-4	0.1096	0.0085	0.0056