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in the Context of Trans-Eurasian Transport

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Transport Connectivity in Northeast Asia: in the Context of Trans-Eurasian Transport[I]

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Abstract

As China has promoted the Belt and Road Initiative (BRI) since 2014 and some CIS countries including Russia established the Eurasian Economic Union (EAEU) in 2015, trans-Eurasian land transport has gained attention. Under this background, this paper examines two questions. The first question is how significantly the recent strategic policies such as BRI and EAEU could shift container cargo from maritime shipping to land transport. The other is how much the shift could affect individual countries and regions in Northeast Asia. To answer these questions, the authors estimate their impacts on cargo volume using the intermodal network simulation model. The simulation results indicate that the cargo volume shifted would be about 10 percent of the total container flows between Asia and Europe, under our assumptions. Although land transport can potentially increase cargo volume several times its current level, maritime shipping will remain the dominant mode in intercontinental cargo transport. In addition, the simulation reveals possible negative impacts on the Primorye region of Russia and Mongolia, while the shift will advance.

1 Background

Transport connectivity is one of the most fundamental preconditions for regional economic integration. Without smooth movements of people and goods, we cannot expect economic exchange in a region.

With this understanding, a vision for Northeast Asia Transport Corridors was proposed as an output of international joint research organized by ERINA (Northeast Asia Economic Conference Organizing Committee, Transportation Subcommittee, 2002). The proposed network of nine corridors consists of two layers; intra-regional and trans-Eurasian layers. The intra-regional layer was translated into Trans-Greater Tumen Region (GTR) corridors,

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[I] A vital part of this paper was presented at an international conference "Key Trends in Transportation Innovation – 2019," 24-26 of October 2019, Khabarovsk, Russia (Shibasaki et al., 2019).

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which the Greater Tumen Initiative (GTI), an intergovernmental regional cooperation mechanism in Northeast Asia, promotes (GTI, 2013).

In this paper, we focus on trans-Eurasian transport, because it has been recently paid more attention, as China has promoted the Belt and Road Initiative (BRI) since 2014 and some CIS countries including Russia established the Eurasian Economic Union (EAEU) in 2015. Although trans-Eurasian land transport has a long history dating from the ancient Silk Road era, the industrial development in recent centuries has strengthened maritime shipping via the Indian Ocean to transport a huge amount of cargo between Asia and Europe. Consequently, land transport plays a minor role in the modern economic geography.

Under this background, this paper examines two questions. The first question is how significantly recent strategic policies such as BRI and EAEU could shift container cargo from maritime shipping to land transport. The other is how much the shift could affect individual countries and regions in Northeast Asia. Particularly, we focus on the impact of reducing the barriers at national border crossing points (BCPs), because they are peculiar to land transport, and significantly affect its connectivity.

In the next section, the authors review the current situation of major trans-Eurasian transport services. Section 3 discusses their challenges. Then, simulation results on cargo flow using a traffic assignment model developed by the authors are introduced according to policy scenarios in Section 4. Section 5 concludes the discussions.

2 Overview of Trans-Eurasian Transport

2.1. Classification of Trans-Eurasian Transport

Trans-Eurasian transport generally includes maritime, land and air transport between Asia and Europe. We focus on land cargo transport in this paper, particularly by rail, with consideration of its higher dependence on geographic conditions and connectivity issues than maritime and air transport. Air transport is nearly free from barriers on land from an origin to a destination, except for very limited cases such as unsafe areas of war or conflict. Maritime shipping has more barriers or bottlenecks (chokepoints), including capacity constraint of canals and straits, navigational conditions affected by weather, and security concerns including attacks by pirates. Land transport, however, has more challenges that hinder connectivity. Not only the capacity of the infrastructure, many other issues also exist when crossing national borders from one country to another, including level of the harmonization of carriers' operation along the shipping routes and issues related to the customs formality. For example, the difference in rail gauge among neighboring countries is a major issue for international rail transport.

From a Northeast Asian point of view, trans-Eurasian land transport can be classified into four categories, based on its east-end origin/destination and mode of transport (Table 1). First, if the origin or destination of cargo is Japan or ROK, which is a de-facto island country, it should be transported with multi-modes combining maritime shipping to/from China or Russia and rail transport between Northeast Asia and Europe across the continent. These multimodal transport services are called "land bridge" service. If the eastern end of cargo transport is located in either of the continental Northeast Asian countries (China, Russian Far East and Mongolia), the trans-Eurasian transport ends within the land area; therefore, it is classified as inland transport.

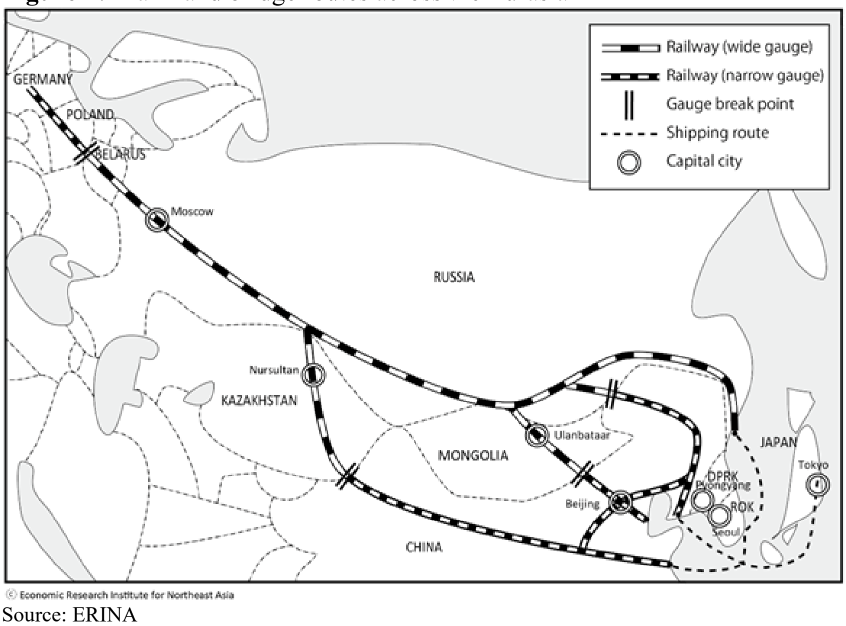
Second, in both multimodal and inland transport, rail transport routes are categorized into two technologically different groups. One is the wide-gauge railway (1520mm) found along the routes with their eastern ends at seaports or cities in Russian Far East. The other group is standard-gauge railway with (1435mm) at their eastern ends of sea ports or cities in China, which requires transshipment operations at Chinese borders with neighboring countries (i.e. Russia, Mongolia and Kazakhstan), different from the former routes connected with Russian Far East.

Table 1: Classification of trans-Eurasian transport and representative service brands

East End of Route	Inland Rail	Multimodal
Russian Far East	Trans-Siberian Railway (TSR)	Siberian Land Bridge (SLB)
China	China Railway Express (CRE)	China Land Bridge (CLB)

Note: Originally, TSR is the name of railway line. In this table, however, it is interpreted as a service brand carrying freight along the TSR, which represents a narrow definition of the term. In a broader sense, the term TSR encompassed all the services shown in the table. For further explanation of the term, please refer to the text.
Source: Author

Figure 1: Main land bridge routes across the Eurasia



Source: ERINA

So far, various transportation companies have developed trans-Eurasian transport service products with or without specific brand names. In the following sections, we review the major transport services listed in Table 1.

2.2. Trans-Siberian Railway and Siberian Land Bridge

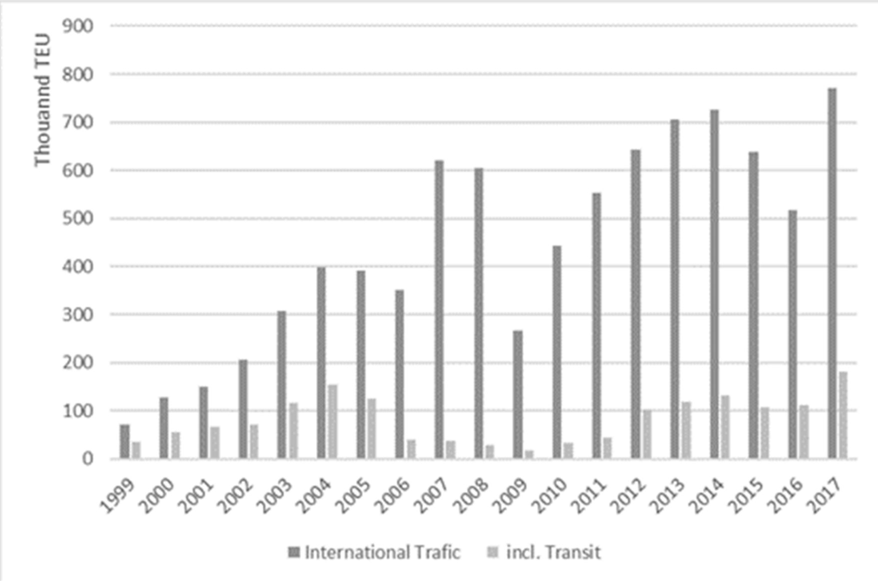
The Trans-Siberian Railway (TSR) is the longest railway line in the world, stretching across the huge territory of the Russian Federation from Moscow to Vladivostok (Figure 1). It functions as a main artery for domestic transport in Russia, as well as for international transport across the Eurasian continent. In the 1970's, Japanese transport companies developed the Siberian Land Bridge (SLB) service, a multi-modal container transport service between Japan and Europe, together with their partners in the USSR. The key motivation was to open the shortest freight transport route from Japan to Europe taking the advantage of existing infrastructure of the TSR.

At the early stage of its development, the brand name of the SLB was a synonym of international container transport along the TSR. The situation has changed since its start, especially during the recent two decades. As mentioned above, the original SLB was the name of the transit service going through the territory of the USSR between Japan and Europe. However, transport routes have been expanded to cover ROK and China on the Eastern side, as well as Afghanistan and Iran on the Western side. When the Soviet Union collapsed at the end of 1991, transportation towards the former Soviet Union countries other than Russia also became "transit" transportation via Russia. Along the expanded transit routes, bilateral transport between Russia and other Asian countries became more important, as Russia developed economic relations with these countries. Recent rapid progress of the China Railway Express (CRE), which use certain section of the TSR, has significantly expanded the coverages, as discussed later. As various international container transport services using the TSR have been developed as such, the original route of the SLB was reduced to just one of them.

Consequently, there are confusions in use of the terms. Some people still use the term SLB as a representative noun of the entire international transport using the TSR, understanding that the SLB is the name of the service, whereas the TSR is a name of rail line representing the physical infrastructure. Those who are more aware of the recent developments of international rail transport routes tend to use the term "TSR (container) transport" as a general noun for these services, not specifying particular routes and/or services. A problem is its ambiguity. For example, sometimes TSR transport is defined as the whole international transport using the TSR, even if some services use a mere short segment of the TSR. In other cases, it excludes the CRE or some other specific routes/services, depending on the subjects of discussion. On the other hand, in the narrowest sense, "TSR transport" represents domestic transport that is completed within the TSR line only.

The volume of international container transportation through the TSR has shown an increasing trend after 2000, although some significant fluctuations were observed in the second half of the '00s, as shown in Figure 2. More importantly, the share of transit transport has reduced significantly during this period. Transit numbers peaked at 155,000 TEU in 2004, and not until 2015 was this figure surpassed again. The recent majority of international container transport is bilateral transport between Russia and neighboring countries, reflecting the increase in bilateral trade between Russia and China.

Figure 2: Dynamics of TSR international container traffic



Source: CCTT (2016 and 2018)

A big challenge for the SLB in the 1990s was punctuality. To overcome it, the block train system was introduced. The block train generally represents a railway train dedicated for container transport connecting from an origin station to a destination station with a fixed route and schedule and without any changes of train formation on the way. It has a significant advantage over a conventional freight train in terms of speed, punctuality, regularity and less vibration.

When the block train succeeded in securing the targeted punctuality to a certain extent, the Russian Railway (RZD) focused on speeding up the service. With the slogan of "Siberian Railway 7 days," RZD started a new project in 2009, aiming at operating a train running through a distance of more than 10,000 kilometers from the Far Eastern Russian ports to the European Union (EU) border in 7 days, at an average speed of over 1,500 kilometers per day. Although it has almost reached the target level in trial runs, the average speed in the regular commercial operation is slightly lower than it. According to the timetables disclosed on websites of rail freight companies available in mid-2018, typical block trains between Far Eastern ports (Vladivostok or Vostochny) and Moscow take from 7 to 11 days.

2.3. China Land Bridge and China Railway Express

The China Land Bridge (CLB) service was developed with a similar concept to the SLB in the 1990's. Instead of the Far Eastern Russian ports for the SLB, the CLB planned to use Chinese ports, such as Lianyungang, selected as the main gateway port of the CLB developed by the Ministry of Railway, as well as Tianjin and Qingdao. The containers arriving at these ports were to be transshipped to freight trains, which ran through Chinese territory to the west, crossed the China-Kazakhstan border and traveled further west. It was announced that the CLB service could deliver containers to European cities. In its definition, the CLB was a multimodal transport service, as classified in Table 1.

The efforts to start the new multimodal transport, however, achieved little success, due to its complicated operations, which we discuss later. For a long time, the CLB was a minor service, mainly targeting a niche market of freight from Japan or ROK to Central Asian countries, including Kazakhstan and Uzbekistan.

The situation of Chinese routes has changed dramatically this decade. In 2013 President Xi Jinping announced the Silk Road Economic Belt initiative, which eventually became a part of the Belt and Road Initiative (BRI), together with another concept for a 21st-century Maritime Silk Road. As the BRI has developed, the original multimodal CLB service has taken a step back, receiving even less attention from clients. Instead, newly developed trans-Eurasian container trains between China's inland cities and Europe have gained significant attention.

For China's inland cities, such as Chongqing, Chengdu, Xi'an, Wuhan, and Urumqi, the land transport to Europe is more economically feasible than the coastal area of China as well as Japan or ROK, because of the following two reasons. First, the land transport distances from these Chinese inland cities to Europe are shorter than those to/from Chinese coastal, Japanese and Korean cities. Second, for Chinese inland cities, land transport of a certain distance to/from Chinese seaports is eventually necessary for access to the trans-continental maritime shipping between East Asia and Europe via the Indian Ocean, which makes maritime shipping less attractive for inland shippers/consignees.

Under this background, the first block train connecting inland China and Europe was launched from Chongqing to Duisburg in March 2011. The block train between China and Europe obtained a new brand name; the China Railway Express (CRE), which gave a new impact to the trans-Eurasian transport, as introduced below.

Table 2 shows the dynamics of CRE container freight transport from 2011 to 2017. One can observe that there was difficulty in securing a certain amount of freight in the initial stages until 2013. However, both the number of trains and the freight amount started to increase rapidly from 2014, after the Silk Road Economic Belt initiative was announced in the fall of 2013. Also, the growth of the CRE contributes to the increase in international freight transport on the TSR, as practically all the CRE trains go through certain section of the TSR at the moment[1].

One of the earlier challenges facing the CRE was the imbalance of freight volume between the two directions. Eastbound freight volumes (from Europe to China) were much lower than those for westbound trains, forcing operators to pay additional costs to return empty wagons and containers. As shown in Figure 3, there was no eastbound freight in the first three years. In recent years, however, eastbound freight volume has increased and now totals almost half that of westbound traffic.

Figure 3: Block train container traffic between China and Europe

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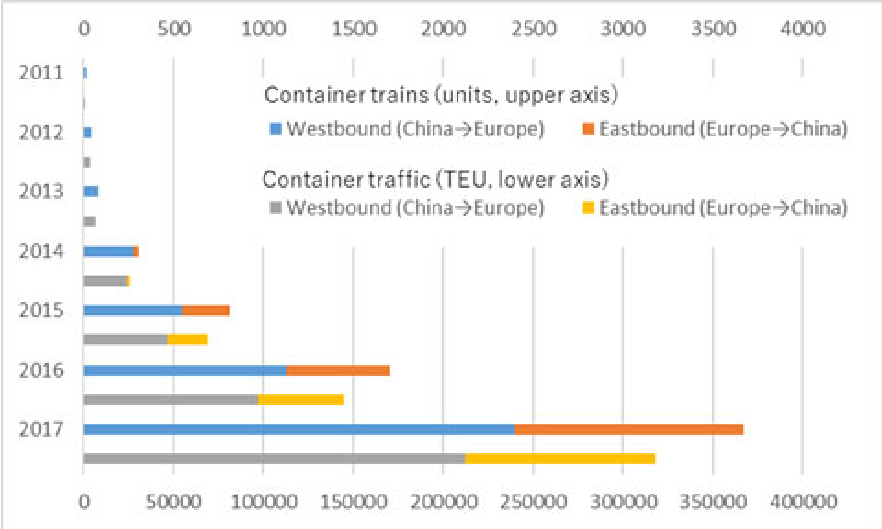
[1] Among potential alternative routes bypassing the TSR is a route through China-Kazakhstan-(Caspian Sea)-Azerbaijan-Georgia-(Black Sea)-Europe, which is not commercially viable at the moment, due to a complicated scheme of transport.



Source: Compiled by authors from EDB (2018) and others

For the breakdown by commodities in recent CRE transport, machinery accounts for about half of total transport volume in both directions, followed by iron and steel, mineral products and chemical products (EDB, 2018). In addition, cloth and glass/pottery occupy a certain potion in westbound services, whereas paper and wood make up a certain amount in eastbound trains.

Another recent feature is that the number of departing and arriving cities and their geographical coverage are expanding in both China and Europe. The CRE trains depart and arrive from not only the aforementioned inland cities in China but also from coastal cities such as Lianyungang, Tianjin and Yiwu, as well as Shenyang and Harbin in the northeast. As shown in Figure 4, geographical coverage in the Western world has also expanded, with routes linking initial destinations such as Russia, Poland, and Germany to Spain in the west, to South Caucasian countries (Armenia, Azerbaijan, Georgia), and further south to Turkey and Iran. As the CRE services geographically expand, the Chinese government has identified three major directions as summarized in Table 2. The Middle and East Corridors are merged to the West Corridor-1 at their western end. The West Corridors-2 and -3 are planned routes and not clearly separated from each other, although some segments are currently in operation for regional transport.

Figure 4: China-Europe Railway routes planning scheme

Source: Leading Group Office on the Construction of the Belt and Road (2016)

Table 2: Major directions of CRE services

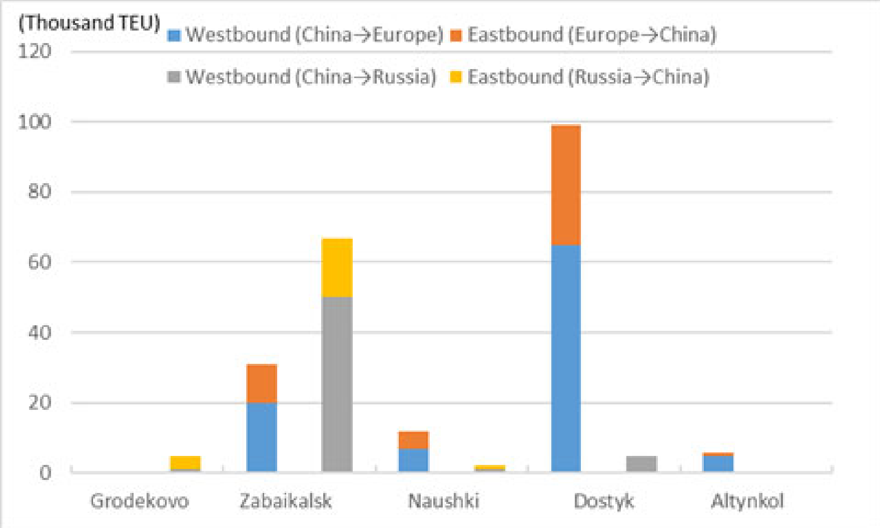
	Status*	Line*	Entry point to EU	Transit countries	BCPs on Chinese national border	Neighboring country at the Chinese BCP
West Corridor-1	In operation	Red	Poland	Kazakhstan, Russia and Belarus	Alashankou - Dostyk, Khorgas - Altynkol	Kazakhstan
West Corridor-2	Planning stage	Red	(by sea)	Kazakhstan, Azerbaijan, and Georgia	Same as above	Kazakhstan
West Corridor-3	Planning stage	Red	Greece	Kazakhstan, Kyrgyz, Uzbekistan, Turkmeni-stan, Iran and Turkey	In addition to the above, Kashgar - Irkeshtam	Kazakhstan or Kyr-gyz
Middle Corridor	In operation	Green	Poland	Mongolia, Russia and Belarus	Erlian - Zamyn uud	Mongolia
East Corridor	In operation	Blue	Poland	Russia and Belarus	Manzhouli-Zabaikalsk	Russia

* Status and line color refer to Figure 4.
Source: Compiled by authors from Figure 4

In addition to the BCPs listed in Table 2, China and Russia has two railway BCPs on their easternmost border, namely Suifenhe - Grodekovo and Hunchun – Kraskino, which are located out of the CRE network (Figure 4) and expected to play certain role in transport of intra-regional trade goods within Northeast Asia, in particular bilateral trade goods between China and Far East Russia.

As observed in Figure 5, the West Corridor-1 is the main route of the CRE, whereas majority of China-Russia container freight move along the East Corridor.

Figure 5: Block train container traffic by BCPs (2016, thousand TEU)



Source: Compiled by authors from EDB (2018) and others

3 Challenges

3.1. Competition among trans-Eurasian Transport Services

There is a two-fold competition structure in the trans-Eurasian transport market. In a broader perspective, land transport, including multimodal transport of the SLB and CLB, competes with other modes of transport, i.e. maritime and air transcontinental transport. In addition, there is a competition among various routes/services of land transport. In this section, these two kinds of competitions are described respectively.

Both maritime shipping via the Indian Ocean through the Suez Canal and air transport by direct flights are traditional modes for the transport of freight between East Asia and Europe. Although the SLB and the CLB have been developed as the third option for intercontinental transport since the 20th century, they remain as minor options for container transport. The volume of international containers transported by the TSR (771 thousand TEU) was only a few percent of the total amount of containers transported by maritime shipping between Asia and Europe (23.7 million TEU) in 2017[2].

Generally speaking, there are several factors to define competitiveness of transport services, including cost, speed (shipping time), service frequency, safety, punctuality, and flexibility. In most cases, cost and speed play a decisive role in the choice of transport service for the shippers from economical viewpoints. Also, safety is one of the most fundamental criteria to evaluate transport services, which implies that freight should be delivered to the

[2] Data of the amount come from CCTT (2018) for the TSR and Japan Maritime Center (http://jpmac.or.jp/relation/european_container_pdf/e2017-12.pdf) for the total amount.

destination without loss or damage. In the modern logistics industry, transport services lacking acceptable minimum safety standards have no chance to compete with other services. Significance of the other factors vary depending on specific features of supply chain of the transported goods.

In the context of inter-modal competition in the trans-Eurasian freight transport market, land transport services are positioned between air and maritime transport in terms of cost and speed. Table 3 gives us an example of typical comparison among the transport modes in terms of cost and time. Wuhan is an inland industrial city in central China, located almost 600 km in a straight line from Shanghai. Therefore, it is necessary to use truck or river shipping before loading the cargo onto ocean-going vessels at seaport.

Table 3: Cost and time between Wuhan and Hamburg by transport mode

MODE	COST (USD/FEU)	TIME (DOOR-TO-DOOR)
Air	14,000~15,000	4~5 days
Rail	4,000~5,000	around 20 days
Truck and Sea	> 4,000	40 days
River and Sea	2,000	51 days

Source: Tsuji (2016)

Even though Table 3 describes the competition structure clearly, one should note that it is not an accurate comparison. First, its figures are not strict, because it is a summary of interviews with business people who follow a rule of thumb. As the CRE service has developed rapidly along various routes, there are no market prices nor price indices. In addition, oceangoing freight charges by maritime shipping heavily fluctuate. Another issue is that Chinese local governments heavily subsidy the fare of CRE, which practically distort the economic balance of each transport mode, as discussed in the following section.

3.2. Enhanced Competitiveness by Subsidies

All CRE routes have been led by local governments in China, aiming at the development of regional economy through better access to European and other markets in the Eurasian continent. This is why local governments enthusiastically support their "own" CRE, by providing significant subsidies. As shown in Table 4, the amounts of subsidies are substantial, varying from 20 to 70 percent of original freight charges. In fact, the subsidies play a significant role in launching CRE services, because they are not competitive without significant discounts enabled by the subsidies. Few private transport companies could have started the services taking all the risks related to huge investments in a form of the initial discounts. At the same time, it should be noted that the subsidy distorts the nature of fair competition. It should not be continued for a long time.

Furthermore, subsidy policies of Chinese local governments are not transparent. They do not publicize the amounts of subsidies. In this regard, the amounts displayed in Table 4 may be anecdotal ones; however, we may conclude that the competitiveness of each CRE service greatly depends on the amount of subsidy provided by the regional authority overseeing it, rather than normal tariff before discounting, shipping time and other aspects on service quality.

Table 4: Subsidies provided by Chinese regional authorities for selected westbound CRE routes

Subsidising Chinese Administration (Direction)	Route	Distance, km	Transit Time, days	Effective Year	Through Freight Rate, $ per FEU	Subsidy Amount, $ per FEU	Average Subsidised Freight Rate, $ per FEU
Chongqing–EU	Chongqing–Duisburg	11,000	15–17	2011	8,000 – 9,000	3,500–4,000	4,750
Hubei–EU	Wuhan–Czech Republic, Poland	10,700	15–17	2014	12,000	4,000–5,000	7,500
Sichuan–EU	Chengdu–Łódź	9,965	12–14	2013	8,500–10,290	3,000–3,500	6,150
Henan–EU	Zhengzhou–Hamburg	10,245	16–18	2013	10,500	3,000–7,000	5,500
Jiangsu–EU	Suzhou–Warsaw	11,200	12–15	2014	7,500	1,500	6,000
Zhejiang–EU	Yiwu–Madrid	13,052	21	2014	10,000	5,500	4,500

Source: EDB, 2018

3.3. Border Crossing Issues

National borders or BCPs represent severe barriers for international transport, where carriers should face additional costs and time for border crossing operations, including customs formalities and transshipment. For improving competitiveness of a trans-continental land transport route, one should consider ways to reduce the number of border crossing and/or burdens (costs and time) at BCPs. Thus, addressing such border crossing issues contributes to enhance the competitiveness of land transport against maritime transport.

There are wide range of approaches to reduce barriers at BCP. One direction is the development of physical infrastructure, such as connecting a missing link of road or railway across the border and expanding transshipment facilities at a border station. Another approach is through institutional arrangements, such as establishing international rules, harmonized standards and guidelines, which are indispensable for the normal functioning of international transportation infrastructure. In the following, major recent developments of institutional arrangements in the Eurasian continent are described.

One of the recent topics in institutional arrangements for international economic activities in Eurasia was the establishment of the Eurasian Economic Union (EAEU) in January 2015. It has five member states; Armenia, Belarus, Kazakhstan, Kyrgyz and Russia. As the EAEU functions as a customs union, their territories as a single customs territory expand in the Eurasian continent as an only transit country between China and EU. Therefore, the number of virtual BCPs that the CRE train connecting between China and EU countries has to transit is only two if the CRE uses the West Corridor-1 (between China and Kazakhstan, and between Belarus and Poland) or the East Corridor (between China and Russia, and between Belarus and Poland), while the routes via the Middle Corridor (between China and Mongolia, between Mongolia and Russia, and between Belarus and Poland) and the West Corridor-2 & -3 are disadvantaged in that they have to cross a larger number of borders.

A milestone in facilitation of rail freight transport on the scale of the Eurasian continent was the introduction of a unified consignment note which was jointly developed by Intergovernmental Organisation for International Carriage by Rail (OTIF) and Organisation for Co-operation between Railways (OSJD). OTIF was established in 1893, which has 49 member states and one associate member, covers almost all EU countries, Russia, Ukraine and some countries from Caucasus, North Africa and Middle East. Another key intergovernmental arrangement for railway transport in Eurasia is OSJD, established in 1956 by the USSR, East European countries and East Asian socialist nations. It currently has 29 member states, including all former USSR countries except for Armenia and some East Asian countries such as China, Democratic People's Republic of Korea (DPRK), Mongolia, ROK and Vietnam. The ROK is the latest member, which joined OSJD in 2018.

One objective of these two organizations is preparing a uniform legal regime for the international carriage of goods across the territory of their members, which simplifies service contract negotiations between carriers and clients (shippers/consignees). Each of them has its own convention, namely the Convention concerning International Carriage by Rail (COTIF) for OTIF and Agreement on International Railway Freight Communications (SMGS) for OSJD. The problem was that these conventions were applicable only within each of their territories, which made it complicated when the cargo was transported across both territories. A joint effort to address this issue resulted in introducing the CIM/SMGS common consignment note in 2006. China has implemented the CIM/SMGS consignment note for the container trains running between China and Europe through Chinese railway BCPs to Kazakhstan, Russia and Mongolia since May 2017, which is an important development for the operation of CRE services.

Another example is an institutional arrangement for road freight transport to simplify custom clearance procedure using a specialized document called "TIR Carnet," supported by the Convention on International Transport of Goods under Cover of TIR Carnets (TIR Convention). The convention came into force in 1978 in Europe, and has since expanded its geographic coverage, resulting in 68 contracting parties at the present. The USSR was a member state of the TIR Convention and its status was succeeded to Russia: all other CIS countries joined in the 1990's and Mongolia signed in 2002. Finally, China ratified the TIR Convention in 2016; therefore, a truck with the TIR Carnet can go through the continent between China and Europe.

4 Policy Simulations on Trans-Eurasian Transport Network

4.1. Model Structure

This paper applies a two-layered network assignment model (NAM) developed from the perspective of shippers by Shibasaki et al. (2017), Shibasaki and Kawasaki (2016) and Shibasaki et al. (2018), to the Eurasian continent including China, Russia, Mongolia and

Central Asia, for the purpose of quantitatively simulating the recent policies that encourage land transport. Figure 6 shows the entire structure of the model, which consists of a super-network for intermodal shipping in the upper layer and two real networks representing each maritime shipping (MS) and hinterland shipping (HS) network in the lower layer. Only full (i.e. laden) containers are considered and regional cargo shipping demand is fixed.

The super-network model in the upper layer includes the outputs of the real network submodels in the lower layer, namely ocean freight charge and shipping time for the MS and LT networks. The maritime and land cargo shipping demands, which are the inputs of the two submodels in the lower layer, are cargo flows of the MS and LT link in the super-network model. The reason why the model is divided into two layers is the consideration of the freight charge, which differs from the shipping cost and is estimated by reference to the path-based, rather than link-based, shipping cost to better reflect reality. Therefore, the different layered networks are necessary to compute both freight charge and shipping cost.

4.2. Data

For computation with the above models, two types of input data must be prepared: (i) the level of service (LOS) in each shipping network and (ii) the cargo shipping demand between regions. The LOS data consist of seaport, MS network and LT network.

4.2.1 Ports

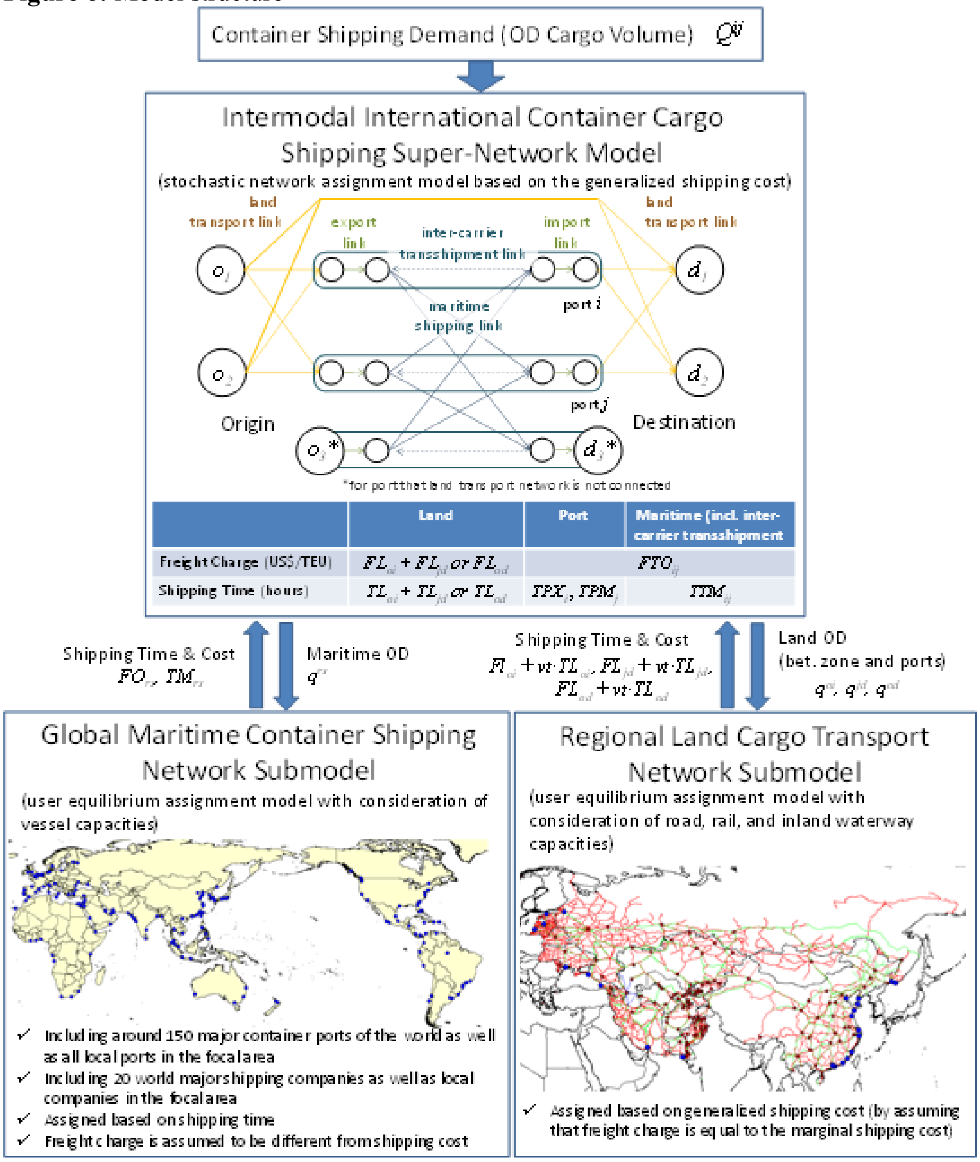
Our model covers the global liner shipping network formed by the major shipping companies. In principle, all container ports whose annual international throughput was more than 500,000 TEU as of 2013 (including empty containers but excluding domestic containers) are included. Additionally, the model includes several gateway seaports (such as Vostochny in Russia, Poti in Georgia and Riga in Latvia) across the Eurasian continent that are not included in the list; thus, the total number of container ports considered in the model is 187.

The lead times at a terminal for export and import and the handling charges at a container terminal for export and import were set by country, by following the 'Doing Business - Trading Across Borders' website provided by the World Bank. We estimated a transshipment time for each port by evaluating the comprehensive level of service in the port.

4.2.2 Global Maritime Container Shipping Network

The MS network is developed based on the MDS containership databank data. Because the model focuses on container flow in the global liner service network and the transshipment of containers at hub ports, some services provided by smaller local companies are eliminated from the network for computational simplicity. Consequently, 1,018 services are included in the model, covering 72.1% of the global annual vessel capacity. For more detailed information on ports and global MS network, see Shibasaki and Kawasaki (2016).

Figure 6: Model structure

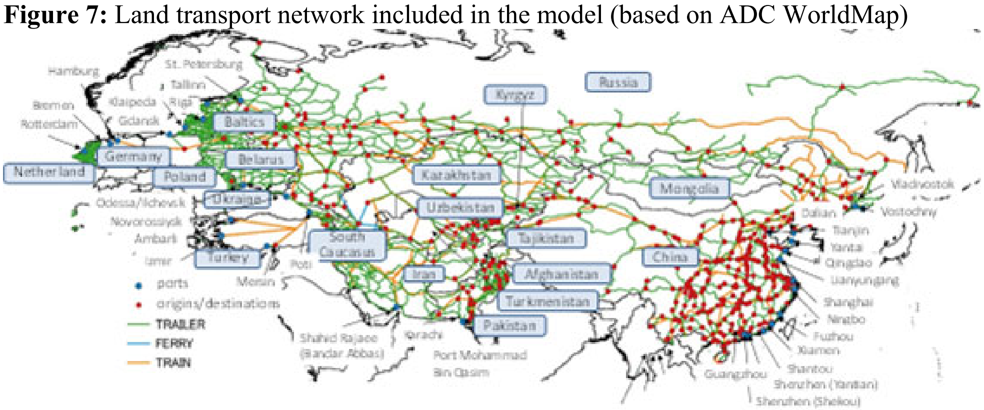


Source: Shibasaki et al. (2018)

4.2.3 Eurasian Land Cargo Transport Network

The LT network covers 24 countries in the Eurasian continent (i.e. Afghanistan, Armenia, Azerbaijan, Belarus, China, Estonia, Georgia, Germany, Iran, Kazakhstan, Kyrgyz, Latvia, Lithuania, Moldova, Mongolia, the Netherlands, Pakistan, Poland, Russia, Tajikistan, Turkey, Turkmenistan, Ukraine and Uzbekistan), as shown in Figure 7. In addition to all road networks and selected rail links which are extracted from the ADC WorldMap, international ferry links in the Caspian Sea connecting Baku in Azerbaijan with Turkmenbashi in Turkmenistan or Aktau in Kazakhstan are included.

Figure 7: Land transport network included in the model (based on ADC WorldMap)



Source: Shibasaki et al. (2018)

4.2.4 Cargo Shipping Demand between Regions (OD Cargo)

The shipping demand for container cargo (container OD cargo) is estimated using various existing data sources. Since this study mainly focuses on route competitions of international maritime containers and their relevant cargo, only maritime containers and 'container-equivalent' land cargo are considered in the model simulation. The OD cargo is made on a TEU (twenty-foot equivalent unit) basis.

Firstly, the OD cargo matrix between countries or regions on a tonnage-basis is obtained from the World Trade Service (WTS) data provided by IHS, Inc. The WTS data provide the container shipping demand among 116 countries/regions of the world in 2013. Note that the shipping demands among European countries (including Russia, Central Asia and the South Caucasus) are not included in the WTS data. The OD cargo matrixes are provided by transport mode (i.e. maritime and land), as well as by cargo type (container, dry bulk, liquid bulk and neo bulk/general cargo) for maritime cargo. However, the matrix of land cargo, which even includes the cargo transported by pipeline, is not categorized by cargo type; therefore, the amount of container-equivalent land cargo is approximately estimated by multiplying a maritime-based containerised rate by commodity which is calculated for each commodity as the share of maritime containers between all types of maritime cargo. The OD matrix of maritime containers is provided on a TEU basis in the WTS data. The matrix of land container-equivalent cargo is converted on a TEU basis from a tonnage basis by dividing into ten, by assuming an average weight of land container-equivalent cargo is 10 tons per TEU.

Secondly, after aggregating the OD matrix into 64 countries/regions to integrate certain countries (e.g. those that are landlocked and those where seaports are not included in the model), they are then divided again on a port basis according to each port's share of the local container cargo throughput for the aggregated region. In addition, maritime containers shipped by companies not included in the model are excluded. This is required to balance vessel capacity with the number of containers shipped in each service in the model computation process. Following these steps, the initial demand of maritime shipping demand is obtained.

Thirdly, a regionally based OD cargo matrix is estimated for 24 countries in the Eurasian continent as described above. The port-based OD matrixes to and from these countries are again aggregated on a country basis. Subsequently, the authors divide them into sub-country levels (zones) such as provinces, federal subjects and oblasts, using the available statistics for the economy of each zone. China is exceptionally divided into a second level of local municipalities (i.e. prefecture-city level) with the customs statistics data which provides the trade amount by partner country and by commodity, because the trade amount in each region of China is significantly larger than those in other countries. Note that the trade amount is the best economic index to represent each zone; however, gross regional product or even population could be used as Shibasaki et al. (2010) indicated, if no other indices were available.

4.3. Model Performance

4.3.1 Modal split in maritime shipping and land transport

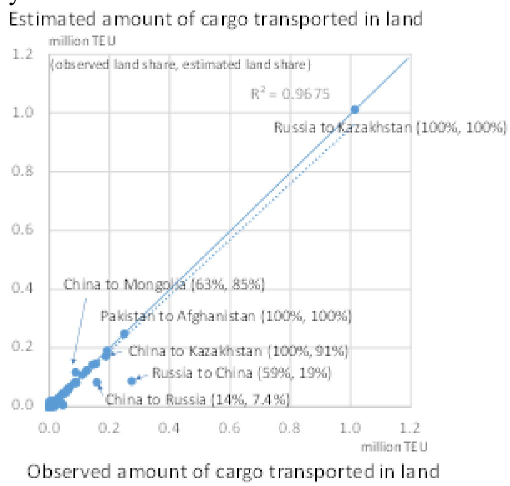
The share of cargo transported by land between the countries in the Eurasian continent, which is acquired from the WTS data, is 4.1% (4.2 million TEU), while that estimated in the model is slightly smaller, 3.7% (3.9 million TEU).

Figure 8 shows the comparison between the observed and model-estimated amount of cargo transported by land by pairs of origin and destination country considered above. It shows that the amount and share of cargo transported by land is well estimated by the model with a few exceptions.

The most significant differences observed are underestimating those between China and Russia, mainly because the model cannot consider the difference in trade-partner countries for each region in Russia (e.g. the actual shares of China as a trade partner for the regions of east Russia may be larger than those for west Russia) due to data availability, while the model can consider that in China, because we could acquire such difference from the China Customs Statistics data.

Another underestimation is observed in the amount and share between China and Central Asian countries including Kazakhstan, partly because the cargo transported by domestic maritime shipping between Chinese seaports have to be categorised as 'maritime cargo' in the model estimation due to the structure of the network, while most of them are classified as 'land cargo' in the WTS data.

Figure 8: Comparison between observed and model-estimated amount of cargo transported by land

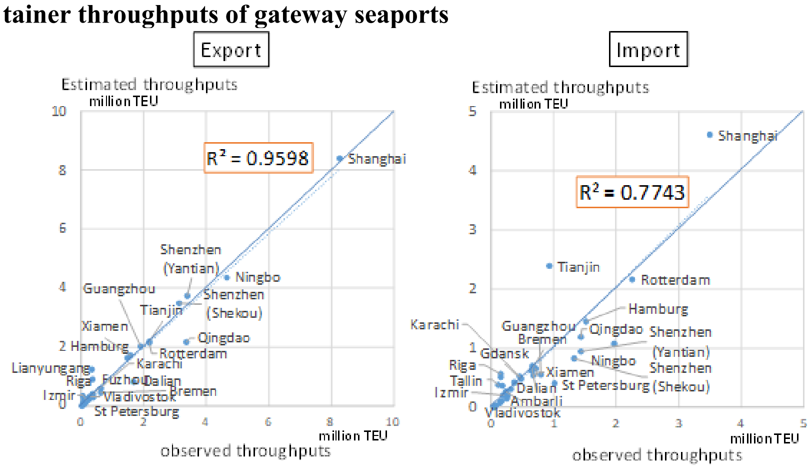


Source: Shibasaki et al. (2018)

4.3.2 Container throughput at each port

Figure 9 compares the observed versus model-estimated export and import container throughputs at gateway seaports across the Eurasia continent. This shows that the model generally estimates the observed throughputs of export and import containers quite well at each gateway seaport. The observed throughputs differ from model-estimated ones at several Chinese ports, such as Lianyungang–Qingdao for export and Shanghai–Ningbo for import. These should be further improved by more focusing on Chinese cargo.

Figure 9: Comparison between observed and model-estimated export and import container throughputs of gateway seaports



Source: Shibasaki et al. (2018)

4.4. Policy Scenarios for Simulation

As we discussed in the section 2, BRI would significantly change the position of land transport on the Eurasian continent, including a shift from maritime shipping and changes of land transport patterns between the SLB and CLB. The simulations in this paper examine the change in cargo volume at Chinese BCPs and seaports, assuming various kinds of policies designed to encourage the use of land transport.

We prepare six scenarios (hereafter referred to as scenario S-1 through S-6) in addition to a baseline scenario, as described in Table 5. Note that the baseline scenario does not replicate the current situation, but instead replicates the situation before launching the CRE without any discounts on tail freight charge. Some of the current promotion measures of the CRE are included in scenario S-1. For example, for reflecting the subsidies provided by Chinese regional governments, rail freight charge for the cargo dispatched from and arriving in China is discounted by 50 percent of the original amount. In addition, average rail speed and frequencies in the countries along the CRE (i.e. China, Russia, Mongolia and Kazakhstan) are doubled to reflect the recent practices in which CRE trains run from China to Europe in around two weeks.

Scenario S-2 is introduced to examine an effect of cross-border facilitation. In the base case, a coefficient on the border barrier at China is set higher than the standard level in the Eurasian continent, considering that its rail gauge (1,435mm) is different from the neighboring Russia, Mongolia and Kazakhstan (1,520mm) and that it had not been a member country of the TIR convention prior to 2018. The coefficient on Chinese border barrier is assumed to reduce at the standard level in the Eurasian continent in scenario S-2. Subsequent scenarios (S-3 and S-4) assume more discounts on rail freight charge than that in S-1 and S-2 scenarios, respectively.

Table 5: Assumed CRE promotion measures by scenario

Scenario	Assumptions
Base	Without any promotion measures (i.e. Replication of the situation before the CRE)
S-1	Basic CRE promotion measures, including - Discounting rail freight charge to/from China by 50% - Doubling average rail speed to 40km/h in the countries along the CRE - Decreasing Caspian Sea ferry freight charge to 1.0 USD/km - Doubling rail frequency in the countries along the CRE
S-2	Reduction of the border barrier level at Chinese BCPs In addition to the measures listed in S-1, - Reducing the border barrier coefficient at Chinese land BCPs by 40% (as the normal level of other Eurasian countries)
S-3	Advanced CRE promotion measures, including, - Discounting rail freight charge to/from China by 80% - Same as the other assumptions in S-1
S-4	S-2 & S-3
S-5	Mongolia enhancement In addition to the measures listed in S-3 - Discounting rail freight charge in Mongolia by 50% - Increasing rail frequency in Mongolia
S-6	Further Mongolia enhancement In addition to the measures listed in S-5 - Reducing the border barrier coefficient at Mongolia-Russian BCP to the EAEU level - Increasing rail frequency in Mongolia and Russia

Source: Authors

Scenarios S-5 and S-6 are additional scenarios dedicated to investigating specific measures for Mongolia. As discussed above, the route through Mongolia ("Middle Corridor" according to China's definition) suffers from a larger number of BCPs along the route than the West Corridor-1 and the East Corridor. In order to enhance the relative competitiveness of Mongolia, scenario S-5 prepares further discount of rail freight charge within Mongolia by half from the level of scenario S-3. Furthermore, scenario S-6 assumes a higher level of facilitation at the Mongolia-Russian BCP, which is comparable to the level of BCP among EAEU member countries.

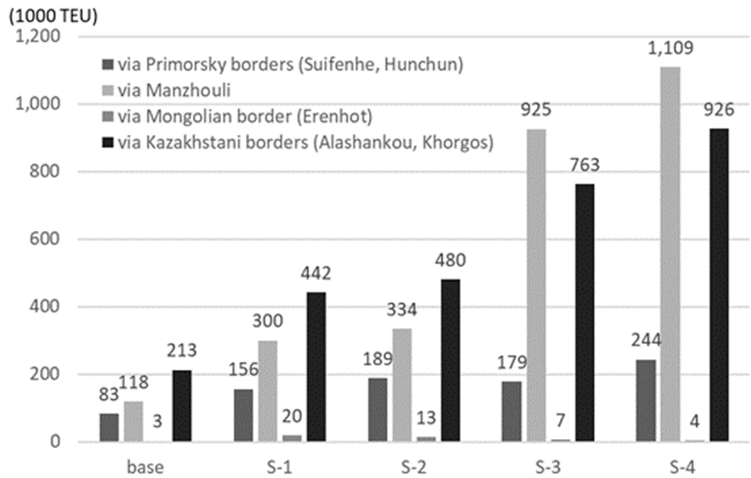
In all cases, throughput capacity is upgraded by increasing service frequency so that it should not limit the potential freight flow generated by the promotion measures.

4.5. Results

4.5.1 Impact of the CRE promotion measures on land transport volume

Figure 10 shows the container cargo volume to transit Chinese BCPs in the baseline scenario and scenarios S-1 to S-4. The volume at the BCPs of Primorye, Manzhouli BCP and the BCPs with Kazakhstan increases as the promotion measures advance. In particular, Manzhouli BCP and the BCPs with Kazakhstan gain much more cargo in cases where the discount rate of freight charge is large (compare the results between S-1 and S-3 and between S-2 and S-4). The impact of reducing the border barrier at BCPs is not stable; it is larger where the freight charge is lower (the cargo volumes in these BCPs increase by around 10% from S-1 to S-2, while they increase by around 20% from S-3 to S-4).

Figure 10: Estimated cargo volume at selected land BCPs of China by scenario



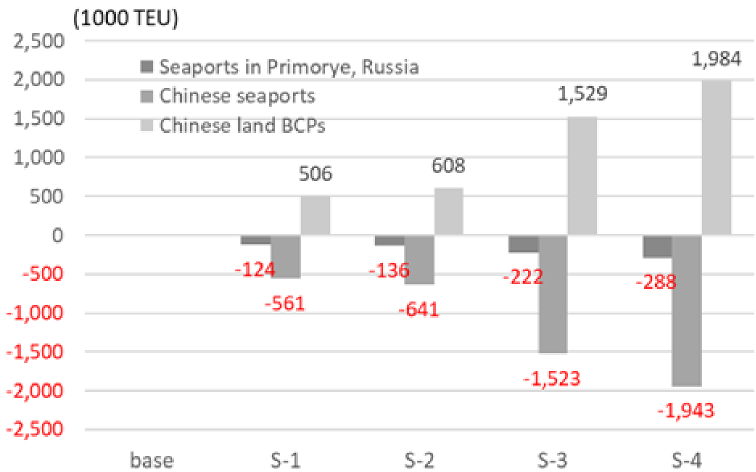
Source: Authors' estimation

4.5.2 Shift from maritime shipping to land transport

As the total volume of cargo shipping demand is fixed at the 2013 level in our model, the increased cargo volume via land borders is thought to shift from maritime shipping. Figure 11 shows the increased amount of cargo at land borders and decreased amount at seaports in China and Russian Far East. It suggests the general magnitude of the shift to transcontinental transport. In scenario S-4, the amount of shifting from maritime shipping to land transport is around two million TEU, which is approximately equivalent to 10 percent of the actual container volume between East Asia and Europe.

In China, the decreased amount of container cargo at seaports is almost the same as the increased amount of cargo at Chinese land BCPs in every scenario, which suggests that the cargo might be generally diverted from oceangoing vessels to land transport under the assumed promotion measures. Nevertheless, there are slight differences between the increased and decreased amount in each scenario. In scenarios S-1 and S-2, the decreased amount at the seaports exceeds the increased amount at the land borders, which may result from a shift for some international cargo from maritime domestic shipping to land transport in China. On the contrary, in scenarios S-3 and S-4, the increased amount at the land borders exceeds the decreased amount at the seaports, which can be explained by the emergence of land transit transport through Chinese territory, for instance from Russian Far East to Central Asia, which currently does not exist in practice.

Figure 11: Estimated change in cargo volume at seaports and land BCPs by scenario



Source: Authors' estimation

4.5.3 Impacts on Russia with a focus on Primorye region

As major transcontinental railway routes transit Russia, the cargo volumes to transit Russia are expected to increase in these scenarios by shifting from maritime shipping. In a huge country, however, the effect of such a shift will differ from region to region. In particular, impacts on the Primorye region, a sea gateway of Russian Far East, will be rather complicated, because seaports in Primorye may lose a certain amount of container cargo that is currently transported from/to the Chinese coastal areas.

First, the shift benefits Russia. According to Figure 10, the increased amount of cargo at the Chinese-Russian BCPs (Suifenhe, Hunchun and Manzhouli) from the baseline scenario varies from 255 (S-1) to 1152 (S-4) thousand TEU. In each scenario, the increased amount at land BCPs significantly exceeds the decreased amount at the seaports in Primorye, which is shown in Figure 11. Moreover, there are additional amounts that transit Russia via the Chinese-Mongolia and Chinese-Kazakhstan BCP.

The shift from maritime shipping to land transport in the Far East is apparent as shown in Figure 12. The figure classifies Chinese provinces in accordance with the share of land transport in the total cargo volume of a province, which are transported to Russian Far East. The area where the majority of cargo is transported by land transport spreads across the whole territory of China in scenario S-3, whereas it covers merely a few Northeastern provinces in the baseline scenario.

The simulation, however, reveals the real risk for Primorye to lose some portion of its transit cargo through the changes. The increased amount at the land BCPs of Primorye shown in Figure 10 is only around 50 to 70 percent of the decreased amount at the Primorye seaports shown in Figure 11 in each scenario.

The gap between the increased amount of land transport and the decreased amount of maritime shipping can be explained by the possibility of a shift from maritime shipping to other land transport routes. For example, cargo transported from China to western Russia, which is originally carried by maritime shipping from a China's seaport to a port in Primorye and then by rail to the destination, may be shifted to one of the land transport routes either via Manzhouli, Mongolia or Kazakhstan, not going through any land BCPs in Primorye.

As a consequence of all these changes, as shown in Figure 13, major transport routes in eastern Russia gain additional cargo volume, with an exception of great loss at the easternmost section connected to the seaports in Primorye.

4.5.4 Case study for Mongolia

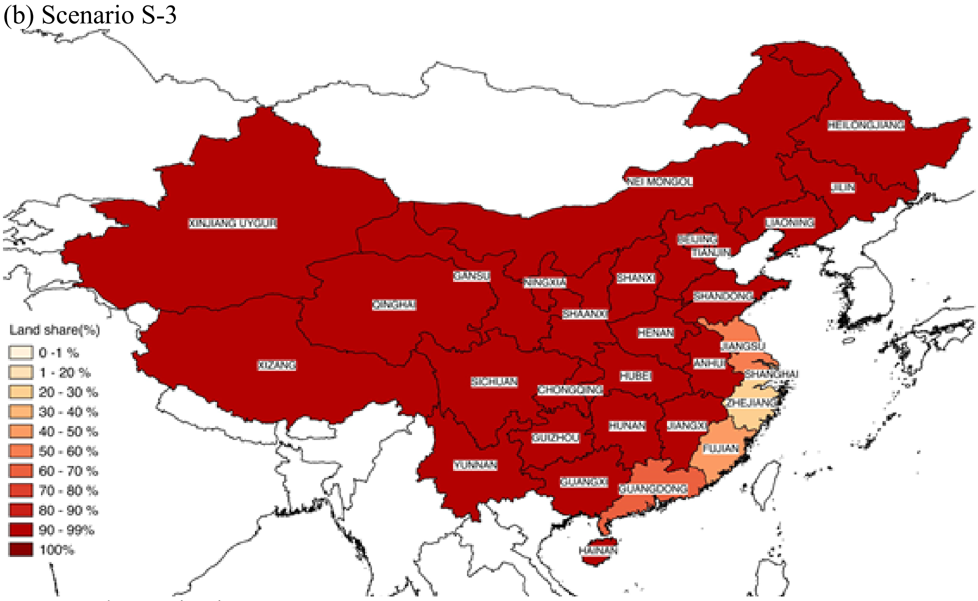
Figure 10 shows how the CRE promotion measures assumed in the four scenarios (S-1 to S-4) benefit Mongolia. The impact, however, is small in each scenario and becomes smaller as the scenario advances. In other words, the measures to promote the CRE generally enhance the relative competitiveness of Manzhouli and Kazakhstani routes against the Mongolian route.

Therefore, we prepare additional scenarios, S-5 and S-6, for investigating possible countermeasures for Mongolia to catch up, taking scenario S-3 as a reference scenario (see Table 5). Figure 14 shows the simulation results, presenting cargo amount at the selected BCPs. The cargo amount to transit Mongolia increases in scenarios S-5 and S-6, while the amounts to transit Manzhouli and Kazakhstani borders decrease in scenario S-5. However, those in scenario S-6 are expected to increase from those in scenario S-5 as with the Mongolian border, implying that the total amount of land transport increases by shifting from maritime shipping.

Figure 12: Share of land transport in total cargo amount shipped from each Provinces of China to Russian Far East

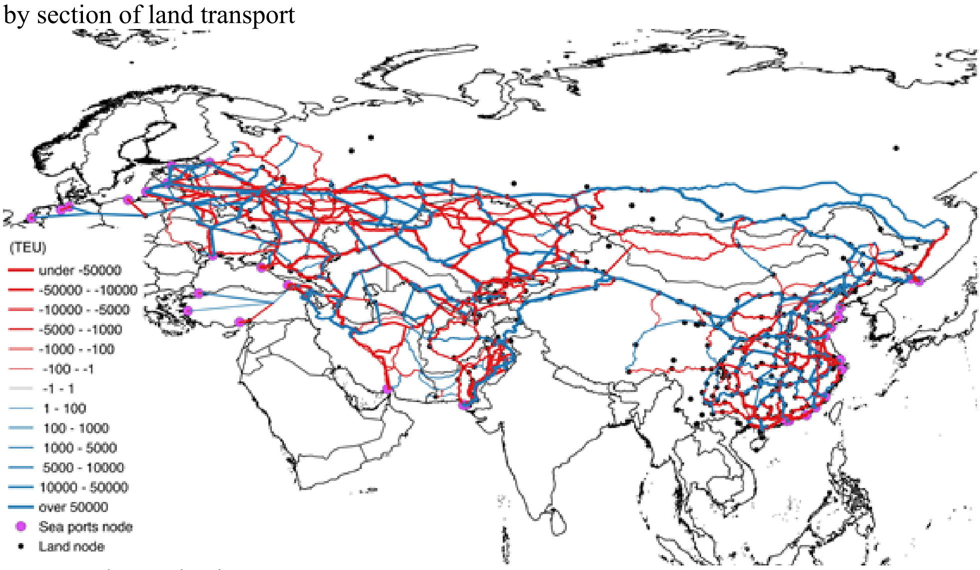
(a) Baseline Scenario

(b) Scenario S-3



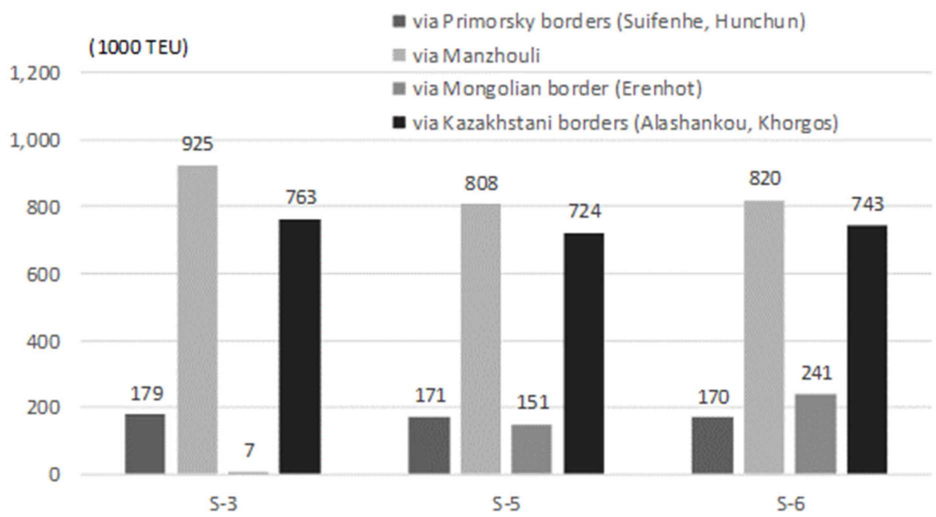
Source: Authors' estimation

Figure 13: Estimated change of cargo flow from the baseline scenario to the scenario S-4 by section of land transport



Source: Authors' estimation

Figure 14: Estimated cargo amount at selected land BCPs of China for Mongolian enhancement scenarios



Source: Author's Estimation

5 Conclusions

This paper argues the impacts of recent strategic policies on trans-Eurasian transport. BRI and EAEU enhance transport connectivity in the Eurasian continent through improving infrastructure and transport services and reducing barriers at BCPs. The enhanced connectivity increases the competitiveness of land transport against maritime shipping, which should lead to a shift of container cargo from maritime shipping to land transport. A question is whether the shift would fundamentally change the current balance between these transport modes. Another question is whether all countries could benefit from the changes. To answer these questions, we estimated their impacts on cargo volume using the intermodal network simulation model.

The following are the key findings through our simulation and policy implications thereof.

First, the shift from maritime shipping would be rather modest. Under the scenarios we assume, the cargo volume shifted would be around 2 million TEU per year in maximum, which accounts for about 10 percent of the total container flows between Asia and Europe. Although land transport has the potential to increase cargo volumes several times its current level, maritime shipping will still be the dominant mode in intercontinental cargo transport.

In addition, the simulation reveals that the reduction of freight charge is most effective for attracting cargo among the promotional means examined. The current discounts of rail freight charge are available owing to subsidies from the regional governments of China. Such subsidies should be a short-term measure for the sake of sound development of the market; they cannot be everlasting, considering the fiscal constraint. A key to further development of land transport is reducing its cost through pursing scale economy and operational optimization, which may substitute the subsidies in time.

With regard to the second question, we focused on Russia and Mongolia.

In the case of Russia, although the country could gain a net increase in volume through the cargo shift from maritime shipping, the Primorye region, a Far Eastern gateway of Russia, might lose a certain amount of transit cargo. Taking into account the importance of the Far Eastern region in terms of balanced regional development of the country, the federal government should implement some counter-measures dedicated to Russia’s regional transport industry.

The Mongolian route may become relatively less competitive against the other routes, when the freight charge decreases further. Our simulation suggests that further reductions of freight charge and barriers at BCP in Mongolia may mitigate the problem, without falling into a zero-sum game with other routes. Three countries (Mongolia, China and Russia) are recommended to jointly address this issue with a spirit of reciprocity.

The main contribution of our work in this paper is to estimate the impact of recent strategies on trans-Eurasian transport quantitatively. We hope that the outcome could promote further policy development aiming at improving connectivity under the international cooperative framework.

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References

Coordinating Council on Trans-Siberian Transportation International Association (CCTT) (2016). *Annual TSR Digest 2016.*

-- (2018) *Annual TSR Digest 2018.*

Eurasian Development Bank (Centre for Integration Studies) (2018). *Silk Road Transport Corridors: Assessment of Trans-EAEU Freight Traffic Growth Potential.*

GTI (2013). *Integrated Transport Infrastructure & Cross-border Facilitation Study for the Trans-GTR Transport Corridors.*

Leading Group Office on the Construction of the Belt and Road (2016). *Development Plan of China-Europe Freight Train Construction (2016-20)*. [in Chinese]

Northeast Asia Economic Conference Organizing Committee, Transportation Subcommittee (2002). *Vision for the Northeast Asia Transportation Corridors.* ERINA booklet vol.1.

Shibasaki, R., Watanabe, T., Araki, D. (2010). How is Model Accuracy Improved by Usage of Statistics? –An Example of International Freight Simulation Model in East Asia–, *Asian Transport Studies*, 1, 33−45.

Shibasaki, R., Kawasaki, T. (2016). Modelling International Intermodal Container Shipping and Application to South Asia, *6th International Conference on Transportation and Logistics (TLOG 2016)*, 7-9 September 2016, Hsinchu, Taiwan

Shibasaki, R., Iijima, T., Kawakami, T., Kadono, T., Shishido, T. (2017). Network assignment model of integrating maritime and hinterland container shipping: application to Central America, *Maritime Economics & Logistics*, 19(2), 234−273.

Shibasaki, R., Nishimura, K., Tanabe, S., Kato, H. (2018). How Does China's BRI Encourage the Use of International Rail Transport across the Eurasian Continent? ~An Approach by Intermodal Logistics Network Assignment Model, *7th International Conference on Transportation and Logistics (TLOG 2018),* 8-9 September 2018, Dalian, China

Shibasaki, R., Arai, H., Nishimura, K. (2019). *Impacts of Eurasian Transport Connectivity enhancement on Russia*. E3S Web Conf. 135 02001 (2019), DOI: 10.1051/e3sconf/201913502001.

Tsuji, H. (2016). Chuou Tairiku Oudan Tetsudo no Tenkai (Development of China-Europe Transcontinental Railway Transport). *Russia & NIS Business Monthly,* January 2016. [in Japanese]