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Working Paper

Logistics policy analysis and network model simulation for cross-border transport in the Trans-Caspian transport corridor: Global intermodal logistics network simulation (GLINS) model

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LOGISTICS POLICY ANALYSIS AND NETWORK MODEL SIMULATION FOR CROSS-BORDER TRANSPORT IN THE TRANS-CASPIAN TRANSPORT CORRIDOR: GLOBAL INTERMODAL LOGISTICS NETWORK SIMULATION (GLINS) MODEL

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Abstract

The countries in Central Asia (CA) are landlocked and without coastlines. Therefore, the Trans-Caspian Transport Corridor (TCTC) will play an important role in facilitating cross-border logistics in CA, particularly with land transport. To promote interregional collaborations between CA countries for managing these handicaps, the CA Regional Economic Cooperation (CAREC) Program was established through the leadership of the Asian Development Bank (ADB). This study focuses on the effectiveness of logistics policy and infrastructure development for cross-border transport along the TCTC using a simulation analysis based on a network equilibrium assignment model. The global logistics intermodal network simulation (GLINS) model, which the authors developed to cover intermodal freight transport networks (including roads, railways, ferries, and maritime shipping across the Eurasian continent) is used for policy simulation in the CA. In particular, the simulation incorporates the impact of the logistics policies related to cross-border transport in the TCTC, including the improvement of ferry services and rail networks along the corridor. The simulation results support the Kazakhstani approach, which emphasizes transit time reduction and transport tariffs while simultaneously enhancing cooperation within the Trans-Caspian International Transport Route Association.

Keywords: logistics, network equilibrium model, Eurasian landbridge, Central Asia

JEL Classification: C63, R42

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1. INTRODUCTION

The countries in Central Asia (CA), which are Kazakhstan, Uzbekistan, the Kyrgyz Republic, Tajikistan, and Turkmenistan, are all former republics of the Soviet Union. They are all inland (landlocked) countries with no ocean coastlines. Although Kazakhstan and Turkmenistan have inland water ports in the Caspian Sea, all CA countries must utilize an overland route through neighboring countries to access a seaport and global trade. To promote international collaborations between the CA countries for managing these transport handicaps, the CA Regional Economic Cooperation (CAREC) Program was established in the mid-1990s through the leadership of the Asian Development Bank (ADB) along with the World Bank, United Nations (UN), and others. Since then, progress has been made in reducing friction at CA regional borders, developing infrastructure, and implementing economic cooperation. Other than the CA countries, member countries of the CAREC Program include the People's Republic of China (PRC), Pakistan, and Azerbaijan, but the Russian Federation is yet to join. One important objective of the program is to improve the interconnections between these partner countries and the CA countries. The Russian Federation, Kazakhstan, and Belarus launched the Eurasian Customs Union in 2010 and expanded it to the Eurasian Economic Union (EAEU) in 2015 with the Kyrgyz Republic and Armenia, which have lowered barriers at their borders with member countries.

The PRC currently promotes the Belt and Road Initiative (BRI). The overland route across the Eurasian continent consists of important parts of the BRI. Railroad container transport from the PRC to Europe and the Russian Federation, which passes through Kazakhstan, has rapidly increased in recent years, and the Kazakhstan government has enacted policies to further accelerate this traffic. Kazakhstan aims to diversify the transit routes throughout its territory, and the Trans-Caspian Transport Corridor (TCTC) has great potential to provide an alternative route to southern Europe and the Near East.

Many reports describing a comprehensive summary of the logistical environment of the CA region have been published by international organizations such as the ADB (ADB 2014 and 2020), the World Bank (Rastogi and Arvis 2014), and Eurasian Development Bank (Lobyrev et al. 2018; Vinokurov et al. 2018). Tanaka et al. (2014) suggested that partial statistical data on international cargo volume could be obtained from the customs records of each country, but such data often contain incorrect or biased information. Yang and McCarthy (2013), Smith (2016), and Wang and Yeo (2018) are examples of research focusing on Kazakhstan's logistical environment and international transport routes. Furthermore, from the Russian Federation perspective, Zuenko and Zuban (2016) compared the competitiveness of the route via Kazakhstan with the route via the Russian Federation Far East. Tanabe, Shibasaki, and Kato (2016) and Shibasaki et al. (2019a) analyzed the expected impacts of improved border-crossing services on international freight transport in CA using a freight traffic network assignment model.

This study focuses on Kazakhstan as a crossroad country at the heart of the Eurasian continent. As a country where transit cargo to and from the PRC is diverted to various directions, Kazakhstan plays a leading role in the development of the TCTC. In this paper, the authors summarize the current status of logistics in Kazakhstan based on a document survey and on-site interviews. Then, the global logistics intermodal network simulation (GLINS) model, which the authors developed to cover the Eurasian continent in the context of the PRC's BRI (Shibasaki, Arai, and Nishimura 2019b;

Shibasaki et al. 2020), is extended to simulate the impact of Kazakhstan's policies on logistics and cross-border transport in the TCTC. This includes the improvement of ferry services and rail networks along the corridor. The simulation results would support the decisions of related policies on infrastructure development for cross-border transport within the international collaboration framework. Although the TCTC refers to a route connecting the PRC and Europe via the Caspian Sea, it is less competitive than the ocean transport route and the land transport routes through the Russian Federation because it crosses more national borders. Therefore, the simulation focuses on the eastern section between the PRC and the Caucasian countries, Iran, and Turkey. This study also aims to highlight considerations regarding future prospects, especially from the perspective of the effects on the transport of cargo originating in Kazakhstan.

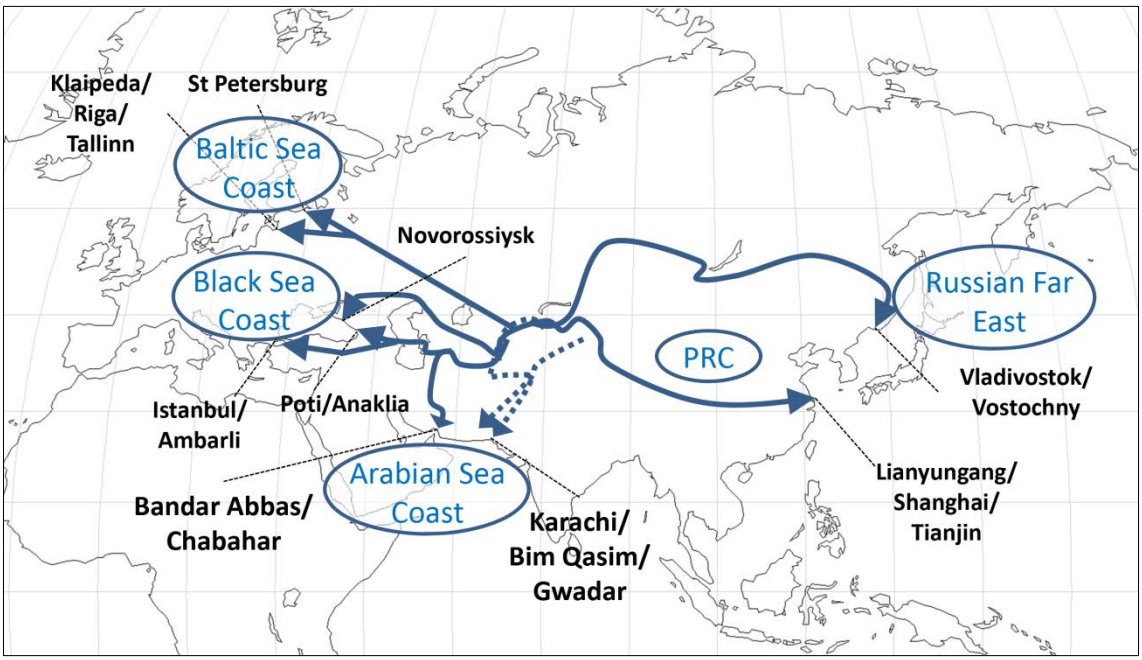
This paper is structured as follows. In Section 2, the current status of international logistics in Kazakhstan, including how transit has been boosted through the PRC's BRI, is discussed. Section 3 describes the proposed simulation model, scenarios, and results. In Section 4, the impact of the COVID-19 pandemic on the TCTC is explained. Finally, our conclusion and policy recommendations are contained in Section 5.

2. CURRENT STATUS OF INTERNATIONAL LOGISTICS IN KAZAKHSTAN

2.1 Overview of Sea Access Routes from Kazakhstan

Figure 1 shows the main gateway seaports to and from CA countries, including Kazakhstan. As shown in the figure, the Eurasian continent broadly covers three directions divided into six routes.

Figure 1: Main Gateway Seaports to and from CA Countries



Source: Shibasaki et al. (2019a).

The shortest overland route from CA to a seaport is to the south, which leads to ports on the Arabian Sea. The most commonly used seaport to the south is Bandar Abbas in Iran. There is current investment in a route from the Xinjiang Uygur Autonomous Region over the Pamir Mountains, which will give direct access to Pakistan. If a link is made to Pakistan via high-grade highways and rail, then in the future, cargo from CA can also travel via the PRC to ports in Pakistan. For the eastern direction, used in most cases for transport to the Far East and Southeast Asia, there are two major routes to access the seaports in the PRC and the Russian Federation Far East.

In the western direction, there are also two main routes to reach CA. One is the TCTC, which involves multimodal transport routes that combine a ferry over the Caspian Sea and land transport routes through the Russian Federation, South Caucasus countries, or Turkey. Both ways reach the Black Sea ports, including Novorossiysk (the Russian Federation), Poti (Georgia), and Ambarli (Turkey). In Georgia, the Anaklia Deep Seaport is under development as a new container terminal for transit over the Black Sea. In 2017, the Baku–Tbilisi–Kars (BTK) railway opened as a transport corridor connecting Azerbaijan and Turkey via Georgia. The other route in the western direction goes to the northwest Baltic Sea, including Saint Petersburg (the Russian Federation) and Riga (Latvia).

2.2 Transit through Kazakhstan Boosted by the PRC's BRI

The PRC's BRI is designed to enhance land freight transport across the Eurasian continent as the PRC develops a landbridge connecting Europe with the Far East. In the Soviet era, the only landbridge across the Eurasian continent was offered through the Trans-Siberian Railway. Eventually, with the breakup of the Soviet Union and the development of relationships between the PRC and CA countries, the focus shifted to the newly developed PRC landbridge (CLB), a shorter transcontinental railway route that connected the PRC with European Russian Federation and European countries via Kazakhstan. In reality, however, the CLB transport was regarded as inferior to sea transport across the continent because it crossed many national borders, including a railway gauge break point at the PRC–Kazakhstan border.

Even though the original concept of the CLB was to connect Japan and the Republic of Korea with Eurasian countries, the focus is now on the transport of cargo originating in the PRC cities because the growth of the PRC's economy has shifted the center for transport of East Asian origin to those cities. In particular, inland cities in the PRC, such as Chongqing, Chengdu, Xian, Wuhan, and Urumqi have dual motivation to develop the landbridge transport: not only is the distance to Europe shorter than that from Chinese coastal cities, Japan, and the Republic of Korea, but the sea transport from those regions requires domestic long-distance transport within the PRC by railway, truck, and inland waterways, which increases the costs and requires more time.

The first container train running between the PRC's inland cities and Europe began in March 2011 from Chongqing to Duisburg and Moscow. Such services eventually gained the brand name of the "China Railway Express" (CRE). Table 1 shows the observed transport volume and the number of container rail services between the PRC and European countries. The table suggests that there were difficulties in securing cargo during the early years. However, from around the fall of 2013 when the BRI was announced, there was a rapid increase in both the number of trains operated and the transport volumes, which doubled each year until 2017. It is frequently suggested that this rapid increase was made possible by political support from the PRC—not only for the investment in infrastructure such as national border facilities and high-speed railways (resulting in an increase in cargo transport capacity for conventional railways),

but also for the subsidies of freight charges provided by the PRC's regional governments.

Moreover, as shown in Table 1, an imbalance in cargo volume for both directions was one of the critical issues of the CRE. Compared with westbound cargo from the PRC to Europe, the transport volume for eastbound cargo (from Europe to the PRC) was insufficient, as demonstrated by the fact that there was no eastbound transport in the first three years of operation. Currently, the eastbound transport volume is about 80% that of the westbound volume, and this is due to the above-mentioned freight discounts and other policy efforts.

Table 1: Number of Container Rail Services and Cargo Volume Between the PRC and European Union (EU) Countries

	Number of Container Rail Services			
Year	**PRC−European Countries**	**European Countries−PRC**	**Total**	**Change from the Previous Year**
2011	17	0	17	
2012	42	0	42	247%
2013	80	0	80	190%
2014	280	28	308	385%
2015	550	265	815	265%
2016	1,130	572	1,702	209%
2017	2,399	1,274	3,673	216%
2018	3,710	2,667	6,377	174%
2019	4,525	3,700	8,225	129%
	Cargo Volume (20-foot Equivalent Units, or TEU)			
Year	**PRC−European Countries**	**European Countries−PRC**	**Total**	**Change from the Previous Year**
2011	1,404	0	1,404	
2012	3,674	0	3,674	262%
2013	6,960	0	6,960	189%
2014	23,804	2,266	26,070	375%
2015	47,132	21,770	68,902	264%
2016	97,400	47,400	144,800	210%
2017	212,000	105,930	317,930	220%
2018	320,252	223,068	543,320	171%
2019	402,130	323,181	725,311	133%

Source: Vinokurov et al. (2018) and Euro–Asia Continental Landbridge Logistics Association.

Another feature of container rail services to and from the PRC is the increase in the number of cities connected on both the PRC and European sides. On the European side, from the original designations of the Russian Federation, Poland, and Germany, there has been an expansion to the west, such as Spain, and to the south, such as the South Caucasus countries, Turkey, and Iran.

The rest of this section focuses on the directions of container block trains within the territory of Kazakhstan. The following description is based on on-site interviews obtained in 2017. The information gathered from these interviews contains data on the railway containers that passed through Kazakhstan on block trains in 2016. The data include containers between countries other than the PRC, but does not include containers to or from Kazakhstan, as shown in Table 2. The CRE (both eastbound and

westbound) passed through Dostyk (and Altynkol' in Khorgos village, partially) on the PRC border and Zhaysan on the Russian Federation border. Meanwhile, a smaller amount of westbound container cargo from the PRC to the Russian Federation passed through Tobol and Semiglavyy Mar on the Russian Federation border.

Rail containers going through Kazakhstan to or from Afghanistan and other CA countries from or to the PRC and the Russian Federation Far East passed through Saryagash as a western exit from Kazakhstan. Containers from the PRC went through Altynkol' (a portion through Dostyk) and those from the Russian Federation Far East passed through Sharbakty or Aul.

Furthermore, containers from the PRC to Turkey were shipped from the Aktau port on the Caspian Sea (although in extremely small quantities), whereas containers from the PRC to Iran were transported via a new railway that opened in 2014 on the east coast of the Caspian Sea, exiting Kazakhstan at the Bolashak station. In addition, a small amount of rail container cargo from Europe to CA started in Latvia, passed through the westernmost region of Kazakhstan in Semiglavyy Mar and Oazis, and reached Uzbekistan or Tajikistan after passing through the Republic of Karakalpakstan in northwest Uzbekistan.

Table 2: Railway Container Freight Volume for Each Border Point in Kazakhstan in 2016

Station (Neighboring Country)	Inbound	Outbound
Altynkol' (PRC)	18,995	266
Dostyk (PRC)	70,728	35,223
Aul (Russian Federation)	8,463	2,490
Sharbakty (Russian Federation)	10,768	23,204
Tobol (Russian Federation)	0	1,164
Zhaysan (Russian Federation)	31,397	69,891
Semiglavyy Mar (Russian Federation)	254	2,132
Aktau (Caspian Sea)	0	166
Bolashak (Turkmenistan)	0	64
Oazis (Uzbekistan)	0	254
Saryagash (Uzbekistan)	29,786	35,537

Source: Authors based on the material provided by the Kazakhstan Forwarder Association.

2.3 Initiatives of Kazakhstan for TCTC

The Kazakhstan government and Kazakhstan Railways (Kazakhstan Temir Zholy, or KTZ) have made efforts to improve the transit environment for international cargo. For example, at borders with the PRC, where cargo must be transshipped because of rail gauge differences, long delays were common at the border a decade ago, but they no longer occur due to improved transshipment facilities in Dostyk and newly constructed facilities in Khorgos. Another important investment is a new railway construction between Zhezkazgan and Beyneu, which creates a shortcut across Kazakhstan between the eastern border with the PRC and the western border with the Russian Federation. The facility development of the Caspian seaports is no less significant, especially from the viewpoint of the development of the TCTC.

At the end of 2019, the Kazakhstan government formulated a state program for infrastructure development called “Nurly Zhol” (Bright Path) for the period from 2020 to 2025(Government of the Republic of Kazakhstan 2019). It provides a wide range of target indicators, including transit container volume, designed to help reach the goal of 1,661,000 TEU in 2025 (compared to 537,000 TEU in 2018). To achieve this goal, the program plans to implement physical and nonphysical measures. The nonphysical measures include simplifying the customs procedures, introducing an E-Transit scheme, and providing online services at My page. Significant railway infrastructure development includes modernization of the Dostyk–Moyynty section, electrification of the Moyynty–Aktogay and Tobol–Nikel’tau sections, and construction of a bypass route between Kokpekty and Karagayly away from Karasor Lake to reduce the risk of flooding.

The TCTC is the focus of the “Nurly Zhol” program, along with the other transit routes across Kazakhstan. According to the program, Kazakhstan continues to explore a sophisticated freight tariff policy for export cargo from Kazakhstan as well as the transit cargo from the PRC, Uzbekistan, and other CA countries along the TCTC. The program is expected to increase the transit cargo volume through the Caspian ports from 0.2 million tons in 2018 to 1.4 million tons in 2025.

As the TCTC passes through multiple countries, the cooperation of all transit countries to promote the route’s usage is a key issue. Kazakhstan plays a leading role by serving as a secretariat of an international association called the Trans-Caspian International Transport Route (TITR), which was established in February 2017 to coordinate all stakeholders involved. As of early 2020, the TITR consists of eight regular members, including the national railway companies from Kazakhstan, Azerbaijan, Georgia, Turkey, and Ukraine. In addition, it involves 13 logistics companies as associate members, including two from the PRC. Members and associate members from Kazakhstan include the KTZ, Aktau Sea Commercial Port, Port Kuryk, Kazmortransflot, and Aktau Marine North Terminal.

The TITR’s efforts to develop the TCTC include promoting marketing activities, enhancing competitiveness, and simplifying administrative procedures. A tangible result of its coordination is a block train service between Lianyungang in the PRC and Istanbul in Turkey, which has been running since November 2018. Another outcome is the April 2019 launch of a regular container short-sea shipping service between the ports of Aktau and Baku in the Caspian Sea.

2.4 KTZ Development Strategy and Caspian Ports

The KTZ gives significant attention to container transport through the country in its development policy. Its latest strategy (approved in 2019) stipulated that it would take all necessary measures to maximize the transit potential by taking advantage of the geographical location of Kazakhstan (Kazakhstan Temir Zholy 2019), as follows:

1. *Enhancing commercial activities in the PRC and Europe*. To achieve the ambitious target of significantly increasing the transit volume between the PRC and Europe, the KTZ should enhance sales in these regions.
2. *Enabling competitive delivery times*. To attract transit cargo, it is essential to minimize the entire delivery time along the transit route. To this end, the KTZ should work on
    - improving the efficiency of the transit system, including increasing the number of container block trains throughout Kazakhstan and minimizing the processing operations of wagons and containers;

- optimizing the length of trains;
- modernizing rail sections with insufficient capacity on all major routes in both Kazakhstan and other countries;
- collaborating with stakeholders in other countries such as the Russian Federation, Belarus, the PRC, and EU countries for increasing rail speed and diversifying directions; and
- increasing the efficiency of container flatcar use on the route to the (South) Caucasus countries and Turkey, which will be achieved through technological innovations.

3. *Realizing competitive freight charges*. The KTZ can optimize freight charges through further implementation of a cost reduction program via optimizing cargo flow routes. This can be done by, for example, fully utilizing electrified tracks and sections, which can reduce the necessity of a physical expansion of rail capacity.

The KTZ has implemented several measures in line with not only the current strategy, but also the previous one. For example, regarding commercial activity, the KTZ Express, a subsidiary of the KTZ that operates block trains as well as transshipment facilities at Khorgos, joined with the operation at the Lianyungang port in the PRC as one of the cross-shareholders for their joint terminal.

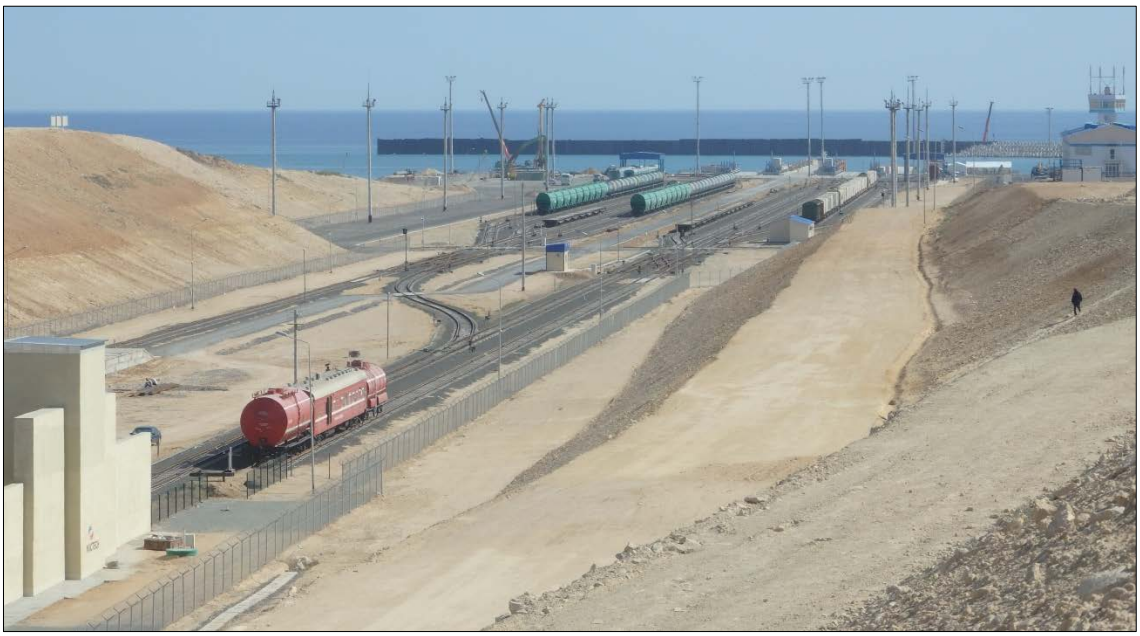
The KTZ development strategy also emphasized the importance of the Caspian ports because the TCTC can connect Kazakhstan more easily with the South Caucasus countries, Turkey, and Eastern European countries via the Black Sea. Because linking the Caspian ports in Kazakhstan with the Baku port in Azerbaijan could avoid passage through other CA countries, namely Uzbekistan and Turkmenistan, improvements for the Aktau port were completed and a new ferry terminal in the neighboring Kuryk district was constructed.

The Aktau port opened in 1963 to transport uranium ore and oil extracted in Mangyshlak. It is operated by the Aktau International Sea Commercial Port, a subsidiary of the KTZ. DP World, one of the world's leading port terminal operators, participates in the operation (it is also acting together with the Khorgos SEZ as an advisor to the KTZ). Major port facilities include a ferry complex, oil terminal, grain terminal, dry bulk terminal, and multipurpose terminal. The ferry travels to and from the Baku port in Azerbaijan in 18–20 hours (253 miles), although most of the cargo is destined for the Iranian ports. The ferry can carry 54 rail freight cars and 35 large trucks, and major items including petroleum products, consumer goods, grains, and fertilizers. Furthermore, the Aktau north port was established in the north of the Aktau port in 2014 and is operated by Aktau Marine North Terminal (AMNT), also a subsidiary of the KTZ. The major port facilities include a grain terminal, general cargo terminal, and container terminal.

The Kuryk port, operated by another subsidiary of the KTZ, is located approximately 60 km south of the Aktau port. The ferry terminal was completed in December 2016 and has been in operation since March 2017 (see Figure 2). Compared with the Aktau port, it has an advantage in that the sailing time can be shortened by about 8%–12% on the sea routes for Iran and Azerbaijan. Between Lianyungang and Istanbul, freight could be delivered in 13–14 days with intermodal transport via the Kuryk port. Expansion plans include a multipurpose terminal, liquid cargo terminal, distribution center, and manufacturing area.

This route would not only provide the shortest route from the PRC and Kazakhstan to the South Caucasus countries and Turkey, but it would also be a transport route to Europe that would not need to transit through the Russian Federation. Thus, it would serve to diversify risk in the PRC's BRI policies.

Figure 2: Ferry Terminal at the Kuryk Port



Source: Authors (2018).

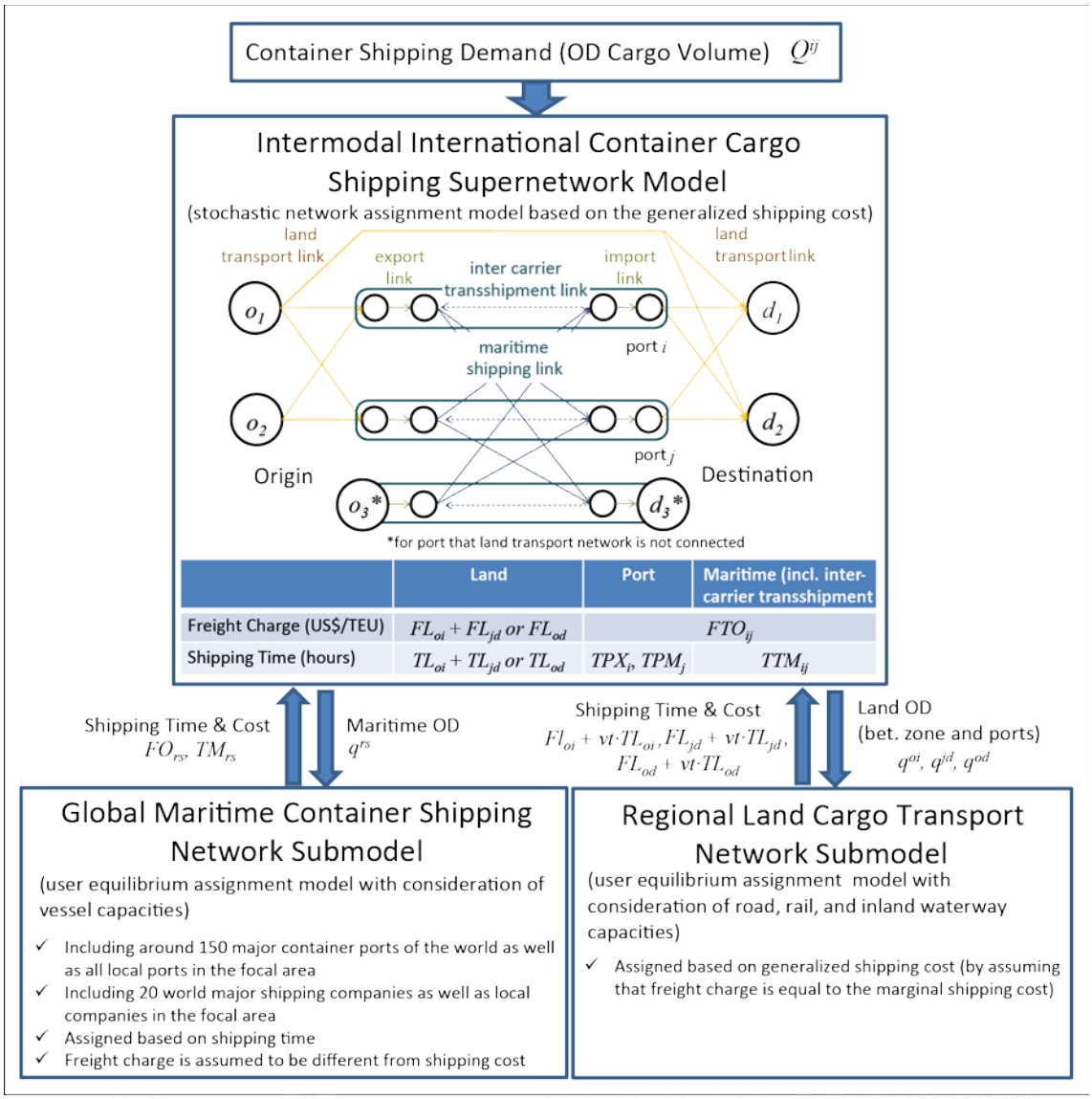
3. SIMULATION MODEL

3.1 Model Description

The authors developed the global intermodal logistics network simulation (GLINS) model for simulating cargo flow on a global intermodal transport network (Shibasaki et al. 2017 and Shibasaki and Kawasaki 2021) and applied it to the Eurasian continent (Shibasaki et al. 2019a, 2020; Shibasaki, Arai, and Nishimura 2019b). This study applies the GLINS model to simulate the impact of the TCTC, mainly from the Kazakhstani perspective. In the GLINS model, which is shown in Figure 3, the cargo shipping demand (maritime containers and "container-equivalent" land cargo are the target of the model) and level of service (e.g., shipping cost, frequency, capacity, speed, and link distance) in transport networks are given as an input, and the cargo flow of each link is an output. The GLINS model is a two-layered traffic network assignment model: the upper layer consists of a stochastic assignment model in the intermodal supernetwork and the lower layer consists of two user equilibrium assignment submodels in the real networks representing maritime shipping and land transport. One of the features of the GLINS model is that it considers the capacity constraint of each transport mode (i.e., roads, railways, inland water transport, and maritime shipping).

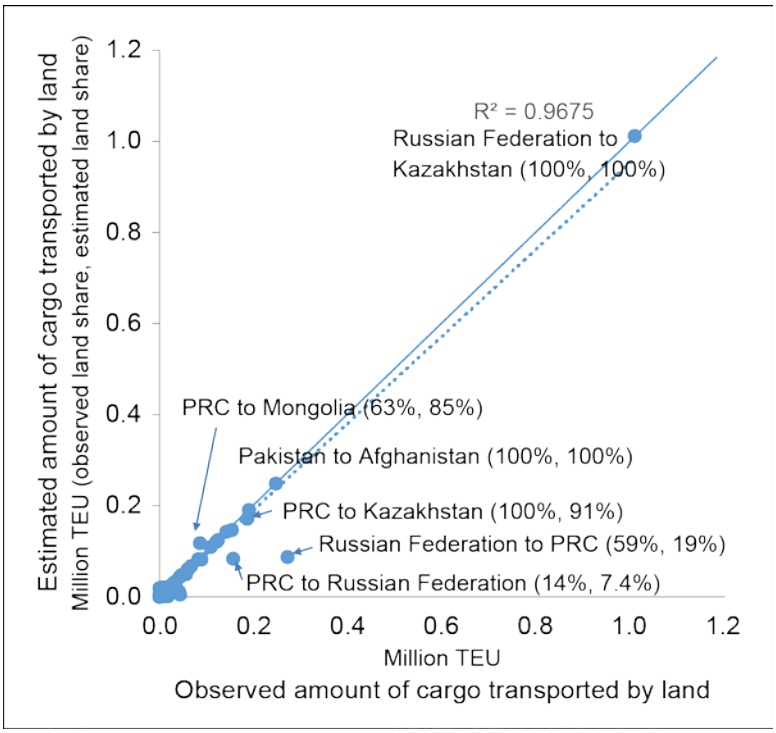
The authors also confirmed how the GLINS model describes the actual situation of global logistics from several viewpoints. For example, the authors can calculate the modal share of maritime containers and "container-equivalent" land cargo for each combination of origin and destination country in the Eurasian continent using the Global Trade Atlas (GTA) forecasting data provided by IHS Markit Inc. The calculated share of cargo transported by land between the target countries in the Eurasian continent was 40.9% in 2016, whereas that estimated by the model was 38.1%. Furthermore, Figure 4 compares the calculated amount and share of cargo transported by land for a combination of countries with those estimated in the model. As shown in this figure, the amount and share of cargo transported by land are estimated accurately by the model, with only a few exceptions.

Figure 3: Structure of the GLINS Model



Source: Shibasaki, Arai, and Nishimura (2019b).

Figure 4: Comparison Between Observed and Model-Estimated Amount and Shares of Cargo Transported by Land



Source: Shibasaki et al. (2020).

3.2 Simulation Scenarios and Results

Based on the discussions in this study, five stepwise scenarios on the promotion of the TCTC other than the baseline scenario are prepared for the model simulation, as described in the previous section. Specifically, the authors assume the following policies are implemented to promote the use of the TCTC in the future:

1. *Construction of a new rail in and around Kazakhstan*. We include the new construction of railways across Kazakhstan in the east–west direction as well as those connecting Kazakhstan and Iran via Turkmenistan along the Caspian Sea, which were not included in the original network.
2. *Speeding up rail transport in Kazakhstan*. We assume the average train speed in Kazakhstan is twice that of the current speed (20 km/h).
3. *Increasing frequency of the Caspian ferry between Aktau (or Kuryk) and Baku*. The frequency is raised from one per week to three per day.
4. *Reducing ferry usage cost in the Caspian Sea by stabilizing the operation*. The shipping cost via ferry is reduced by a factor of three from 3.0 USD/km/TEU to 1.0 USD/km/TEU.
5. *Reducing freight charges of the CRE by subsidies or other means*. The freight charges of all container trains to and from the PRC are reduced. We assume stepwise reducing rates at 25%, 50%, and 75% for the scenario analysis because, according to the authors' past research, the rate significantly affects the traffic volume (Shibasaki et al., 2020).

6. *Reducing border barriers between the TCTC countries*. The border barriers between the PRC, Kazakhstan, Azerbaijan, Georgia, and Turkey are assumed to be half the current level because this also significantly affects the traffic volume according to research conducted by the authors (e.g., Shibasaki et al. 2019a, 2020; Shibasaki, Arai, and Nishimura 2019b).

Table 3 summarizes the settings of each scenario with the combination of policies (1 to 6). We basically assume the deployment of policies (1 to 4) in Kazakhstan for all scenarios and focus on sensitivity analysis for rate reductions in policy 5) and 6).

Table 3: Scenario Settings for the Model Simulation

Scenario	New Rail Construction and Increasing Level of Service of Kazakhstan Railways and Caspian Ferry (1−4)	Reducing Rate of Freight of the CRE (5)	Decreasing Rate of Border Barrier between the TCTC Countries (6)
Base	No	0%	0%
S1	Yes	0%	0%
S2	Yes	25%	0%
S3	Yes	50%	0%
S4	Yes	75%	0%
S5	Yes	75%	50%

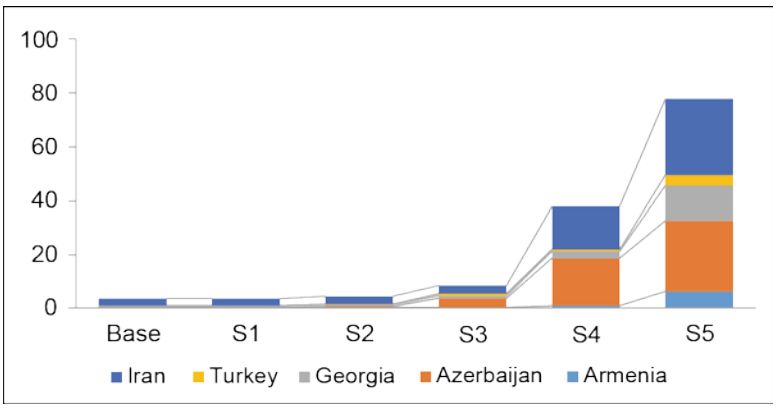
Source: Authors.

Figure 5 shows the estimated annual amounts of laden containers transported by land from the PRC to South Caucasus countries, Turkey, and Iran. Figure 6 also shows the estimated shares of laden containers transported by land from the PRC to these countries. Note that Armenia and Iran are not included in TCTC countries. As shown in Figure 6, in S4, where the rail freight charge is reduced by 75%, the estimated number of containers transported by land significantly increase compared with those in the previous scenarios (i.e., S1 to S3), especially those to Azerbaijan, which shares a border with Kazakhstan via the Caspian Sea.

Moreover, in S5, assuming that the barriers at national borders between the TCTC countries are reduced, the estimated shares of containers transported by land from the PRC to Georgia and Armenia increase. Because these countries share a border with Azerbaijan, the impact of the policies to reduce the shipping and border-crossing costs is extended there. The reason why the share of land transport to Armenia is larger than that to Georgia, despite Armenia not being the target of reducing border barriers, is that Georgia is located on the Black Sea and is easier to access by maritime shipping.

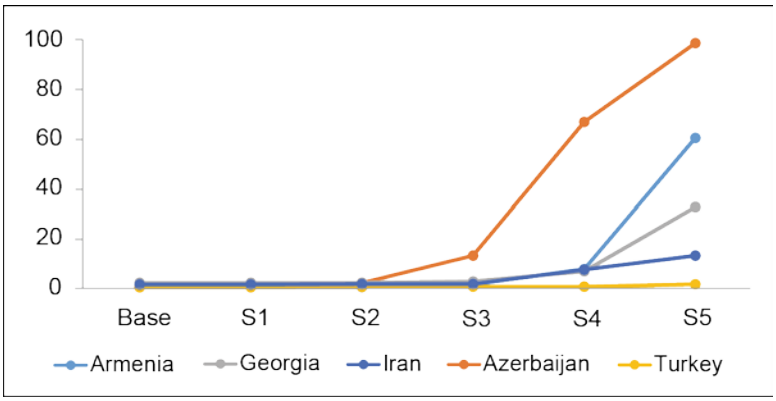
On the other hand, the estimated shares of containers transported by land to Iran and Turkey are still small, even if the land shipping cost is significantly decreased and border barriers between the TCTC countries are reduced. In Iran, the estimated amount of land transport is not negligible, although the estimated shares are small. From this result, if the container ferry in the Caspian Sea between Kazakhstan and Iran is frequently operated and the border barriers between these countries are reduced, we expect the amount and share of land transport would significantly increase. Regarding Turkey, because container trains cross many national borders from the PRC and direct maritime shipping is available from Turkish seaports, it is more difficult to encourage the use of land transport. However, the result from the simulation that some containers use the land route reveals that the land route will function to secure the redundancy of the trade route.

Figure 5: Estimated Annual Amount of Laden Containers Transported by Land from the PRC
(1,000 TEU)



Source: Authors.

Figure 6: Estimated Shares of Laden Containers Transported by Land from the PRC
(%)



Source: Authors.

4. IMPACT OF COVID-19 PANDEMIC ON THE TCTC

The outbreak of COVID-19 has had a significant impact on the global supply chain. Just after the pandemic started in the PRC until mid-February 2020, a large decrease in cargo volume from the PRC to the EU, CA, the Persian Gulf, and South Caucasus countries was observed due to a decline in the factory utilization rate in the PRC. In addition, most air freight services were globally canceled or reduced and airfares were significantly raised, therefore, the cross-border block trains have been used as an alternative to air transport. The number of these services in April 2020 was 976 trains, which was the highest ever recorded in a single month (EACLLA 2020). The block trains were also used to transport epidemic-prevention goods from the PRC to European countries.

The volume of cargo handled along the TCTC has increased significantly due to the pandemic, and close cooperation between ports resulted in the movement of cargo without any delays (Meretkylichev 2020). This fact was presented by representatives from four Caspian ports (including Aktau and Kuryk), who discussed joint measures to

combat the COVID-19 pandemic in May 2020. However, there is still a quarantine requirement for vessels to prevent the spread of COVID-19. The Ministry of Industry and Infrastructure Development of Kazakhstan announced that the transport of people and vehicles with drivers has been temporarily suspended for vessels arriving from Azerbaijan and Iran at the Aktau and Kuryk ports in March 2020. The services of container shipping at the Aktau port and rail transport at the Kuryk port will not be interrupted, but the services of ferry transport at the Kuryk port will be affected by the restriction for vehicle drivers.

As for the effect of COVID-19, there is an advantage of rail transport between the PRC and Europe in terms of redundancy of the logistics network in the long term. In the short term, there is a disadvantage of marine transport across the Caspian Sea due to the quarantine requirement for vessels to prevent the pandemic.

5. CONCLUSION AND POLICY RECOMMENDATIONS

This study focused on the effectiveness of logistics policy and infrastructure development for cross-border transport along the TCTC using a simulation analysis based on a network equilibrium assignment model. The results of the literature review and on-site interview-based surveys in Kazakhstan enabled a summary of international trade and port access routes from Kazakhstan and of the recent rapid increases in landbridge transport via railway containers between the PRC and Europe. Notably, Kazakhstan's national railway, the KTZ, took active initiative in the development of block trains along the TCTC, including port developments in the Caspian Sea. This study concludes that the TCTC has potential as an alternative route to and from Europe, especially eastern and southern Europe, without passage through Russian Federation territory.

This study used the GLINS model, which the authors developed to cover intermodal freight transport networks (i.e., roads, railways, ferries, and maritime shipping) across the Eurasian continent for policy simulation in the CA. In particular, the impact of the logistics policies related to cross-border transport in the TCTC, including the improvement of the ferry services and rail networks along the corridor, were incorporated. The simulation results support the decisions of related policies on infrastructure development for cross-border transport within the international collaboration framework. The major results of the simulation analysis are as follows:

1. As the rail freight charge is significantly reduced (i.e., by 75%), the estimated number of containers transported by land from the PRC to the South Caucasus countries is significantly increased, especially those to Azerbaijan, which shares a border with Kazakhstan via the Caspian Sea.
2. If the barriers at national borders between the TCTC countries are reduced, the estimated shares of containers transported by land from the PRC to Georgia and Armenia are increased.
3. The estimated shares of containers transported by land to Iran and Turkey are still small, even if the land shipping cost is significantly decreased and border barriers between the TCTC countries are reduced.

The simulation results support the Kazakhstani approach, which emphasizes transit time reduction and transport tariffs while simultaneously enhancing cooperation within the TITR Association. As for the limitation of our model analysis, we need to consider the priority for the development of related infrastructure in railway sections and ports in Kazakhstan because we assumed possible policies including new rail construction

and increasing the level of service of Kazakhstan railways and Caspian ferry in all scenarios.

In addition, although it is difficult to foresee how COVID-19 will affect society in the long term, the above-mentioned experiences suggest the importance of redundancy in the logistics network. From this point of view, further investigation, including a simulation analysis of the entire TCTC route between the PRC and Europe, will be required. Another challenge is that this study focused on the cargo to transit through Kazakhstan (which originated from or was destined for the PRC) because of its significant volume. However, the real interest of the Kazakhstani government must be how their policies benefit the Kazakhstani economy. More specifically, it needs to consider how it will reduce the freight transport cost of the cargo originating from or destined for Kazakhstan, and how it will encourage an increase in the cargo volume. To discuss this issue, the simulation analysis in this paper should be integrated with another module, such as that presented in Kumagai et al. (forthcoming), to forecast the future trade amount by considering the economic impact of the decrease in transport costs.

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