

Kumagai, Satoru; Gokan, Toshitaka; Tsubota, Kenmei

## Working Paper

# Corridor developments for transforming Central Asia

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**ADB Working Paper Series**

**CORRIDOR DEVELOPMENTS FOR  
TRANSFORMING CENTRAL ASIA**

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Satoru Kumagai, Toshitaka Gokan,  
and Kenmei Tsubota

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Satoru Kumagai is director of the Economic Geography Studies Group, Development Studies Center, Institute of Developing Economies, of the Japan External Trade Organization. Toshitaka Gokan is a research fellow at the Economic Geography Studies Group, Development Studies Center, Institute of Developing Economies, of Japan External Trade Organization. Kenmei Tsubota is a professor at the Faculty of Global and Regional Studies of Toyo University.

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Please contact the authors for information about this paper.

Email: [tsubota@toyo.jp](mailto:tsubota@toyo.jp)

Asian Development Bank Institute  
Kasumigaseki Building, 8th Floor  
3-2-5 Kasumigaseki, Chiyoda-ku  
Tokyo 100-6008, Japan

Tel: +81-3-3593-5500  
Fax: +81-3-3593-5571  
URL: [www.adbi.org](http://www.adbi.org)  
E-mail: [info@adbi.org](mailto:info@adbi.org)

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**Abstract**

This paper offers a Spatial Computable General Equilibrium Model (SCGE) to evaluate the potential regional economic impacts of the Central Asia Regional Economic Cooperation Program (CAREC) corridors and the Trans-Caspian International Transport Route (TITR). We base our model on spatial economics and incorporate sub-national data over the regions. We also equip the model with multimodal choices among trucks, trains, airplanes, and ships, which are crucial for the analysis of landlocked regions like Central Asia.

Through scenario-based simulations, we find that economic impacts are not spatially limited to the regions with the projects. It is probable that population and industries may shift to regions with better connectivity by virtue of corridor developments. There would also be synergy effects from the implementation of both the CAREC and the TITR corridor, meaning that the two projects have a complementary relationship. Furthermore, the analysis reveals that the economic impacts of the projects may derive largely from the growth in the service sector, suggesting the need for additional public investments, such as Special Economic Zones, to boost industries other than services.

**Keywords:** impacts of infrastructures, economic development, spatial computable general equilibrium

**JEL Classification:** C68, O18, R30

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# 1. INTRODUCTION

Unlocking landlocked regions is a challenge for geographically disadvantaged regions and people as it is important not to leave them behind in developments. Given the location of resources and existing cities, the results of the historical trade structure of regions have shaped the transport networks and reinforced the relationships among regions. Large-scale infrastructure investments, such as the Central Asia Regional Economic Cooperation Program (CAREC) and Trans-Caspian International Transport Route (TITR), are interventions that have the potential to change the existing hierarchy of regions in a system of cities and regions.

The CAREC corridors constitute a set of many international logistics infrastructure projects within an initiative under the leadership of ADB for the international coordination of international infrastructure projects. This is one of the flagships of the CAREC Program. The TITR is a logistics-oriented project stretching from the People's Republic of China (PRC), through Kazakhstan, the Caspian Sea, Azerbaijan, and Georgia to Turkey and European countries. The web page of the organization promoting the TITR, which is a consortium of logistics public companies in these countries,<sup>1</sup> shows that this platform offers integrated logistics along TITR, effective operation, and better processing of customs procedures and border-related administration to promote the competitiveness of user companies.

As the CAREC corridors and the TITR play important roles in the development of Central Asian countries, this paper conducts an economic analysis of these infrastructures. Specifically, to evaluate the infrastructure investments in transportation networks, we developed a Spatial Computable General Equilibrium (SCGE) model based on spatial economics using sub-national data from across the world, which we call the Institute of Developing Economies-Geographical Simulation Model (IDE-GSM). This framework is notable as it employs spatial economics, which allows us to examine the clustering of industries and urbanization, which is called agglomeration economies.<sup>2</sup> Since transport infrastructure developments can potentially change regional economies, such projects are parts of the national development strategies and industrial policies. By showing the possible landscapes at the sub-national level by industry, our results can directly assist the policy makers working on such national developments.

In this paper, we evaluate the CAREC corridors and the TITR and show how they can potentially affect the surrounding regions at sub-national levels and the industries in these regions. Based on the project plan of the CAREC corridors and the TITR, we set the scenario that these projects can reduce transport costs and time. Our scenario-based analyses show that the economic impacts are widely apparent over regions and are not limited to the regions that are directly implementing the projects. As these projects improve the accessibility of some transport links, they affect the accessibility of other regions both directly and indirectly. It is probable that population and industries will shift to regions with better connectivity by virtue of the corridor developments. We also find that the implementation of both the CAREC corridors and the TITR could have larger regional economic impacts than either of the individual projects. We refer to these as synergy effects, suggesting that the projects have a complementary relationship. Furthermore, the analysis reveals that the economic impacts of the

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<sup>1</sup> <https://middlecorridor.com/>.

<sup>2</sup> Spatial economics is sometimes called "New Economic Geography," following Paul Krugman. Krugman (1998) described the original idea well, and Proost and Thisse (2019) published a recent review of the literature.

projects may derive largely from the growth in the service sector, suggesting the need for additional public investments, such as Special Economic Zones, to boost industries other than services.

For clarification, the difference from the Global Trade Analysis Project (GTAP), which is the most popular computable general equilibrium model, consists of two main points: the modeling strategy and the geography. Our model employs product differentiation at the firm level, not at the country level, and it uses sub-national data and transport networks among them. This setup can only allow us to analyze the detailed regional impacts of transport infrastructure projects like the CAREC corridor and the TITR.

The remainder of the paper proceeds as follows. Section 2 briefly explains the scope of the CAREC corridors and the TITR. Section 3 provides the details of our model, the IDE-GSM, such as the structure of the model, data, assumptions for simulations, and scenarios. We also make some brief remarks on our baseline assumption. In Section 4, we present the results of the analyses.

## **2. OVERVIEW: CENTRAL AND WEST ASIAN COUNTRIES**

To provide some snapshots of the regions, this subsection presents our underlying data. We compiled regional gross domestic product (GRDP) data pertaining to three economic sectors, namely agriculture, manufacturing, and the service sector, at the regional level for eight Central West Asian (CWA) countries.<sup>3</sup>

Table 1 provides the summary statistics of the dataset. There are large differences in the population, GRDP per capita, and population density among regions within and between countries. For instance, in Georgia, the region with the largest population has 24 times that of the smallest population. In Azerbaijan, the region with the highest GRDP per capita is 21 times richer than the region with the lowest GRDP per capita. In Tajikistan, the region with the highest population density is more than 2,000 times denser than the region with the lowest population density.

The regional population densities in the CWA countries are generally low. Nevertheless, some regions exhibit higher population densities, such as regions in Armenia, Azerbaijan, and Georgia; the border regions between the Kyrgyz Republic, Uzbekistan, and Tajikistan; and the capital cities of each country.

The GRDP capita for the regions in mountainous areas is relatively low. There are some regions with a higher GRDP and a low population density, which are largely oil-producing regions.

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<sup>3</sup> For the industrial composition statistics, we utilized some data from international organizations and local agencies combined with INDSTAT2 from UNIDO.

**Table 1: Summary Statistics of Regional Data for Central and West Asian Countries in 2010**

	Number of Regions	Population ('000)				GRDP per Capita (USD)				Population Density (person/km <sup>2</sup> )			
		Min.	Mean	Median	Max.	Min.	Mean	Median	Max.	Min.	Mean	Median	Max.
Armenia	11	56	295	279	1,117	989	1,989	1,523	5,359	24	535	74	5,007
Azerbaijan	11	228	818	570	2,065	681	4,623	3,751	13,964	36	159	77	969
Georgia	11	48	404	388	1,152	1,714	2,451	2,242	4,553	10	201	64	1,600
Kazakhstan	16	503	1,013	441	2,512	2,955	11,272	613	37,599	3	335	30	4,360
Kyrgyz Republic	9	229	602	754	1,118	396	867	9,034	2,059	6	2,199	5	12,955
Tajikistan	5	207	1,524	870	2,699	418	738	4,485	1,591	3	1,514	12	7,311
Turkmenistan	6	429	840	1,737	1,151	4,487	4,487	4,487	4,487	3	240	88	1,389
Uzbekistan	14	714	2,000	2,155	3,119	1,299	2,048	1,566	4,286	8	167	146	607

### 3. METHODS

Our research starts by building a general equilibrium model. For clarity regarding the differences of our model from the typical CGE models, we should mention the model, the modal choice, and the data. The model is a monopolistic competition model à la Krugman and contains transportation costs. As we have intra-national and international geography, we have many layers of different transport networks, which allow us to reproduce the complex modal choice by commodities and the combination of regions. Having such transport networks implies that our data are at the sub-national level and by industry. In the following subsections, we briefly explain the setup.

#### 3.1 The Model

We built our model on those of Krugman (1991) and Puga (1999). We focus on seven sectors that we included in the model: agriculture, services, and five separate manufacturing sectors. The agricultural sector uses labor and land as its inputs under constant returns to scale technology. We assume that agricultural land rents accrue to households in the same region. Furthermore, we follow the Armington assumption that goods are differentiated by location.

Manufacturing firms produce under increasing returns to scale technology, which requires the goods produced in the sector and labor. Firms in the service sector use only labor under increasing returns to scale technology. We assume that workers are mobile within countries and between sectors but not among countries. All products and services are tradable. We choose the iceberg-type transportation costs. Specifically, the value of a product melts en route, like an iceberg, for the sake of transportation costs. Thus, only some portions of the value arrive. We assume that there are no costs for transporting goods within the same region. The details of the model are available from Kumagai et al. (2013) and Isono et al. (2016).

#### 3.2 Data

The most crucial variables in our model are the population, regional gross domestic product (GRDP), industrial composition, and area size of arable land. We incorporated these into our geospatial data from various sources. There are three main sources: national statistics, international statistics, and satellite data. When available, we checked the compatibility of the national and international statistics. When national statistics were not available, we utilized the available public data, international



statistics,<sup>4</sup> and satellite data for the industrial or regional decomposition.<sup>5</sup> For each region, we compiled industrial data for seven sectors: agriculture, five manufacturing sectors, and services. The five manufacturing sectors were automobiles, electrical and electronic equipment (E&E), textiles, food processing, and other manufacturing.

For the detailed industrial composition, we looked for the Census of Manufacturing or equivalent information by industry and region. When this was not available, we used the national industrial composition from the national statistics or INDSTAT2, which UNIDO compiled.

For the geographical composition, when national statistics were not available, we utilized two sources of satellite data for regional decomposition. One is the night-time light and the other is the land cover. The former has a strong connection to the manufacturing and service sectors. On the other hand, land cover can capture the agricultural sector. Using these, we decomposed the national total into regional data.

All of the regional data refer to the nodes of the transport networks, and we constructed four layers for road, ship, rail, and air.

### 3.3 Simulation Procedure

The IDE-GSM uses a repeated two-step procedure for its simulation. The first step, for a given distribution of employment and GRDP by sector and by region, obtains the short-run equilibrium. In the second step, given the short-run equilibrium obtained, workers (a mobile factor in our model) migrate to the industry in a region offering the highest real wages. Having this migration of workers, we obtain an updated distribution of employment and GRDP by sector and by region. In our simulation model, one year corresponds to these two steps. By repeating these two steps, we calculate the baseline scenario and other specific scenarios.

### 3.4 Basic Assumptions and Baseline Scenario

We made some basic assumptions for our simulations. 1) The population grows at the speed that the UN Population Division forecast. 2) There is no international migration.<sup>6</sup> 3) The model already includes all changes for tariffs, NTB, and others from the FTA/EPAs currently in effect. 4) The technological progress will occur at the same speed as between 2005 and 2010 for each country.<sup>7</sup> Following these basic assumptions, we simulate the model and obtain the baseline scenario in which there are no infrastructure projects or institutional agreements.

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<sup>4</sup> We constructed these data for these countries from UN data.

<sup>5</sup> See the following website for details on the construction and sources of our data: <http://www.ide.go.jp/English/Data/Geda/make.html>.

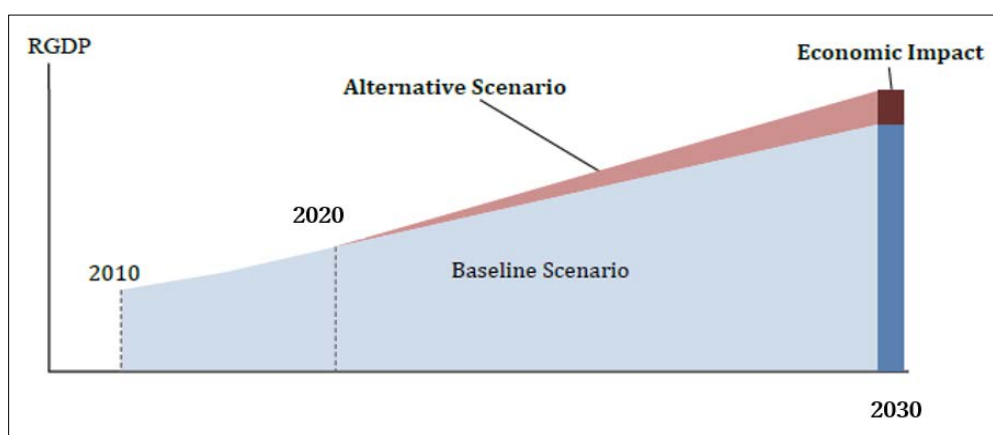
<sup>6</sup> We take this migration parameter from Barro and Sala-i-Martin (1992) and calibrate it to replicate the actual population growth in representative cities during the period 2005–2010. We set our parameter as 0.20. Other studies have shown that it may be around 0.26 for the US and 0.27 for Japan.

<sup>7</sup> Note that, as we know, there are periodical global crises. As of 2020, we are experiencing the coronavirus pandemic. Experiencing such crises and acting against them, we assume that the growth in the following years may be similar to the average from 2005 to 2010. This means that various monetary and fiscal policy measures mitigate the coronavirus pandemic shocks in 2020. The baseline scenario includes all of such policy measures except the infrastructure projects that the text discusses.

### 3.5 How We Evaluate Alternative Scenarios

The alternative scenarios correspond to specific development projects and policy measures in or from the specific year. After translating the alternative scenarios into the operational assumptions on the specific parameters, mainly changing the transportation costs and time, we enforce the simulation procedure. Then, we compare the GRDP and GRDP per capita against the baseline scenario in 2030 or another year. When the GRDP or GRDP per capita of a region under an alternative scenario is higher or lower than that under the baseline scenario, we consider the surplus or deficit as the economic impact (Figure 1). Note that negative impacts for a region under an alternative scenario do not always mean that the region would be worse off than in the current situation. It indicates relatively slower growth than in the baseline scenario, which does not mean that there is negative economic growth.

**Figure 1: Illustrative Image of Regional Impacts: Differences between the Baseline and the Alternative Scenarios (an Example of Positive Impacts)**



Source: Authors.

### 3.6 Assumptions for Road Development

As Section 2 mentioned, we set certain assumptions regarding the speeds of roads by differentiating the quality of the existing roads and that of the upgraded roads. From our observations around East Asia and Southeast Asia, there are broadly three types of road quality: 1) low level (19.5 km/h), 2) intermediate level (38.5 km/h), and 3) high level (80 km/h). On the railways, we set several different speeds for each country as they differ widely among countries. Upgrades in the quality of an existing road imply an increase in the average speed.

### 3.7 The Mechanism

The direct impacts of the projects are the reductions of transportation costs and time. Given the reduction of trade and transport costs and time, the optimal routes for all the regions for all products will change. Then, the increased profitability of firms will result in an increase in wages, and this will call for more migration of people. At the same time, it will encourage the entry of firms into this sector, which will decrease the price index for firms and consumers by expanding the available varieties.

This is the typical mechanism for improving transport infrastructures, which is the main topic that spatial economics analyzes.<sup>8</sup> Our simulation scenarios mostly involve the changes in accessibility measures. With such a reduction in transportation and trade costs, these scenarios will induce the migration of people and firms as well as increasing consumption and sales, which will produce changes in the economic impacts.<sup>9</sup>

We can define the accessibility of each district as the total of all market sizes discounted by the distance between districts. Then, some changes in the accessibility within the networks will inevitably change the accessibility for all districts. Of course, the magnitude of the impacts depends on the proximity and the market size. Consequently, these changes will affect the labor demand, the labor wages, the profitability of firms, and the direction of trade.

## 4. RESULTS

In this section, we show the results in three steps. First, we present the baseline scenario in subsection 4.1. Subsection 4.2 contains the results for individual corridor projects for the CAREC corridor and the TITR. Then, subsection 4.3 provides the results for the combination of the CAREC corridors and the TITR.

### 4.1 Baseline Scenario

We assume that the baseline scenario has minimal additional infrastructure development after 2010. In the baseline scenario, the summary statistics in Table 2 show steady growth in many parts of the world. It is evident that the number of regions in the category with less than 1000 per capita GRDP dropped from 30.5% to 12.7%. Many of the regions graduating from this category are in East Asia or South Asia. In particular, the number of regions with a per capita GRDP in the range between 500 and 1000 dropped sharply. The comparison of the baseline scenario regarding the per capita regional GDP between 2010 and 2030 also shows that inland African regions remain in similar categories.

**Table 2: Transition of Per Capita GRDP from 2010 to 2030**

Per Capita GRDP	2010		2030	
$x < 500$	280	(8.6%)	137	(4.2%)
$500 < x < 1,000$	714	(21.9%)	279	(8.5%)
$1,000 < x < 3,000$	1,095	(33.5%)	1,195	(36.6%)
$3,000 < x < 10,000$	593	(18.2%)	885	(27.1%)
$10,000 < x$	582	(17.8%)	768	(23.5%)
Mean	7,043		9,928	
Median	1,722		3,018	
# of region	3,264		3,264	

Source: IDE-GSM calculations.

<sup>8</sup> See, for example, Redding and Rossi-Hansberg (2017).

<sup>9</sup> See, for example, Fajgelbaum and Schaal (2020).

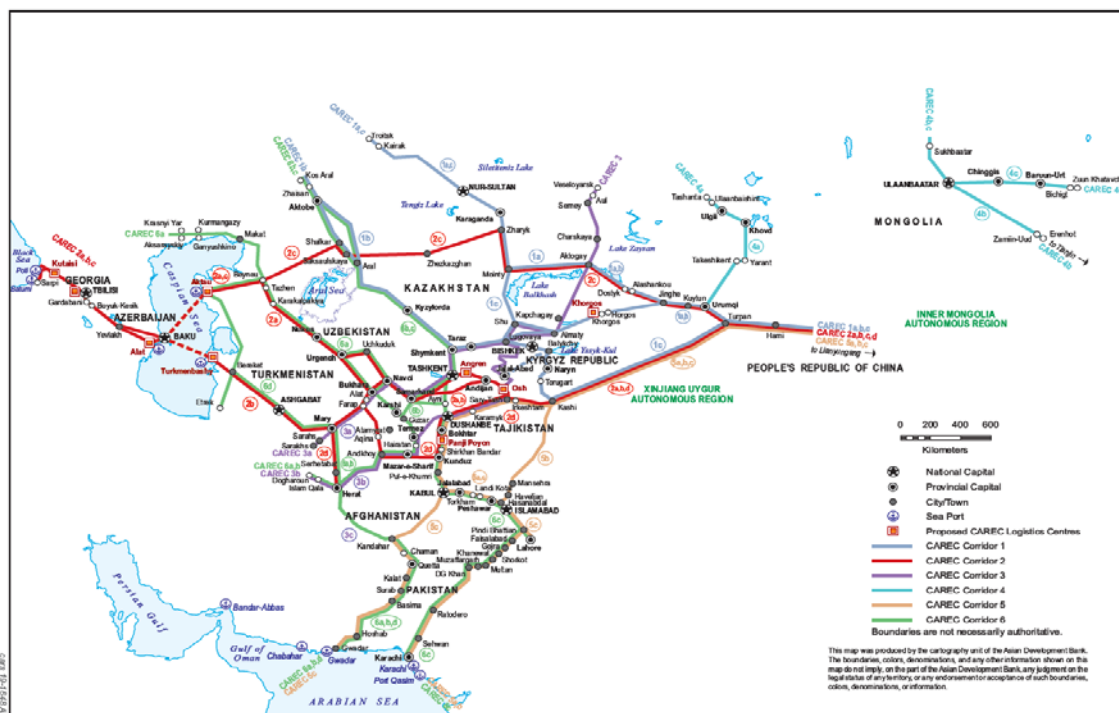
## 4.2 Economic Impacts of CAREC Corridors

In this subsection, we conduct simulation analyses using the IDE-GSM with respect to the combination of the following two types of corridor developments:

- Highways: Raising the average speed of specified roads in the CAREC corridor from 19.25 km/h to 38.5 km/h.
- Railways: Raising the average speed of specified railways in the CAREC corridor from 19.1 km/h to 40.0 km/h.

ADB’s (2020) CAREC Transport Strategy 2030 shows the list of corridors. As the purpose of this paper is to conduct an analysis for Central Asia, we deselect CAREC corridor 4, which is mainly for Mongolia. We also do not include CAREC corridors passing through Afghanistan, Iran, and Pakistan, for which connectivity with Central Asia is still largely lacking and the prospects for the completion of the construction are uncertain. We restrict our analysis to infrastructure improvements. Though it is possible to implement them, we reserve the impacts from trade facilitation for future study.

Figure 2: CAREC Corridors



Source: Map 1 from ADB (2020) or <https://www.carecprogram.org/uploads/carec-designated-rail-corridors.pdf>.

Table 3 contains concise results for each CAREC corridor and for all of the CAREC corridors. The number shows the increase in the RGDP per capita for each region in the country and the standard deviation, the unit being USD per person. The following sections provide an explanation for each scenario in detail.

**Table 3: Simulation Results of the Impacts of CAREC Corridors**

Country	CAREC 1		CAREC 2		CAREC 3		CAREC 5		CAREC 6		CAREC All	
	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.
Armenia	23.71	0.1	44.58	0.2	0.30	0.0	0.00	0.0	4.88	0.2	21.23	0.1
Georgia	8.03	0.0	16.58	0.0	0.09	0.0	0.00	0.0	9.75	0.2	6.63	0.2
Kazakhstan	321.74	7.5	143.37	6.0	43.93	0.6	0.00	0.0	51.76	0.9	152.13	2.0
Kyrgyz Republic	0.78	0.0	0.19	0.0	0.37	0.0	0.04	0.0	0.26	0.0	0.74	0.0
Tajikistan	1.07	0.0	0.21	0.1	0.29	0.1	0.10	0.1	1.04	0.1	1.23	0.1
Turkmenistan	1.01	0.1	22.61	0.7	4.95	0.2	0.00	0.0	12.72	0.5	13.95	0.3
Uzbekistan	1.72	0.0	17.08	0.2	6.97	0.2	0.00	0.0	9.92	0.1	14.35	0.1

Note: Unit is USD/person.

Source: IDE-GSM calculations.

#### 4.2.1. CAREC Corridor 1

CAREC Corridor 1 connects the PRC and Europe through Kazakhstan and the Kyrgyz Republic. Corridor 101 connects Dostyk, in Kazakhstan, near the PRC border, with Kairak, in Kazakhstan, near the Russian Federation border, through Astana, the capital of Kazakhstan. Corridor 102 connects Altyntkol, in Kazakhstan, near the PRC border, and Aktobe, in Kazakhstan, near the Russian Federation border. Corridor 103 connects Torugart, in the Kyrgyz Republic, near the PRC border, and Kairak, in Kazakhstan, near the Russian Federation border, through Chaldovar, in the Kyrgyz Republic; Merke, in Kazakhstan; and Astana, in Kazakhstan. In this scenario, we suppose that the implementation and completion of the road and railway enhancement projects specified as CAREC Corridor 1 will take place in 2020.

Comparing this with the benchmark scenario, we find that the positive impacts are substantive in North Kazakhstan, Akmola, Kyzylorda, and Mangystau. We find that the impacts of the project on each industry in terms of the percentage changes in the per capita real GDP differ among countries. In Armenia, only E&E and services receive negative impacts, and agriculture receives large positive impacts. In Azerbaijan, all industries receive positive impacts. In Georgia, only E&E receives negative impacts, and the other industries receive positive impacts. In Kazakhstan, agriculture and services enjoy huge increases, but other manufacturing receives negative impacts. In the Kyrgyz Republic, services receive positive impacts, other manufacturing receives negative impacts, and the sign of the percentage changes for food and mining differ among regions. In Tajikistan, agriculture, automobiles, and textiles receive positive impacts, but E&E, the food industry, other manufacturing, and services receive small negative impacts. In Turkmenistan, E&E receives negative impacts, but the impact on the specific industry is not as clear since it depends on the location. In Uzbekistan, the agriculture, mining, and other manufacturing sectors benefit, but the food industry receives negative impacts.

#### 4.2.2. CAREC Corridor 2

CAREC Corridor 2 connects the PRC and the Caucasus and Mediterranean regions through the Caspian Sea. The corridor passes through six out of eight CWA countries, namely Azerbaijan, Kazakhstan, Turkmenistan, Uzbekistan, Tajikistan, and the Kyrgyz Republic. Corridor 201 connects Irkeshtam, in the Kyrgyz Republic, near the PRC border, with Aktau, in Kazakhstan, through Tashkent, the capital of Uzbekistan, and crosses the Caspian Sea to Baku, Azerbaijan, and Tbilisi, the capital of Georgia. Corridor 202 connects Irkeshtam and Turkmenbashi, in Turkmenistan, and crosses the Caspian Sea to Baku, in Azerbaijan, and Tbilisi, in Georgia. Corridor 203 connects

Dostyk, in Kazakhstan, near the PRC border, and Aktau, in Kazakhstan, through Zhezkazgan and crosses the Caspian Sea to Baku, in Azerbaijan, and Tbilisi, in Georgia. Corridor 204 connects Irkeshtam and Serhetabat, in Turkmenistan, through Dushanbe, the capital of Tajikistan. In this scenario, we suppose that the implementation and completion of the road and railway enhancement projects specified as CAREC Corridor 2 will take place in 2020.

The positive impacts are strong in Western Kazakhstan, Uzbekistan, and Turkmenistan. The regions along the corridor in Kazakhstan appear to be beneficial, albeit to a small degree. We find that the impacts of the project on each industry in terms of the percentage changes in the per capita real GDP differ among countries. In Armenia, agriculture, mining, textiles, and food receive positive impacts. In Azerbaijan, almost all industries and areas receive positive impacts. In Georgia, agriculture mainly receives positive impacts. In Kazakhstan, agriculture and services mainly receive positive impacts, but other manufacturing receives negative impacts. In the Kyrgyz Republic, almost all industries and regions receive positive impacts. In Tajikistan, the regional difference is clearer than the difference among industries, but services receive positive impacts. In Turkmenistan, the regional difference is clearer than the difference among industries, but agriculture, textiles, and food receive positive impacts. In Uzbekistan, services receive strong positive impacts, but automobiles and other manufacturing receive negative impacts.

#### **4.2.3. CAREC Corridor 3**

CAREC Corridor 3 connects the Russian Federation and the Middle East through Kazakhstan, the Kyrgyz Republic, Tajikistan, Turkmenistan, and Uzbekistan. Corridor 301 connects Aul, in Kazakhstan, near the Russian Federation border, and Sarahs, in Turkmenistan, near the Iranian border, through Tashkent, the capital of Uzbekistan. Corridor 302 connects Semey, in Kazakhstan, and Termez, in Uzbekistan, near the Afghanistan border, through Jalal-abad, in the Kyrgyz Republic, and Dushanbe, the capital of Tajikistan. In this scenario, we suppose that the implementation and completion of the road and railway enhancement projects specified as CAREC Corridor 3 will occur in 2020.

We observe positive impacts along the corridor, and the impacts are stronger in the Navoiy region of Uzbekistan and the Lebap region of Turkmenistan as well as in the Almaty region of Kazakhstan. We find that the impacts of the project on each industry in terms of the percentage changes in the per capita real GDP differ among countries. In Armenia, agriculture and services receive relatively large positive impacts, but other manufacturing receives a relatively large negative impact. In Azerbaijan, except in Nakhchivan, the tendency among industries is clear and only textile and food industries receive negative impacts. In Georgia, all of the manufacturing sectors receive negative impacts, but agriculture, mining, and services receive positive impacts. In Kazakhstan, agriculture, E&E, and the food industry receive positive impacts, but the sign of the percentage changes differs among regions in the remaining industries (services tend to receive large positive impacts). In the Kyrgyz Republic, agriculture and textiles receive positive impacts, but the sign of the percentage changes in the remaining industries differs among regions. In Tajikistan, the sign of the percentage changes differs among regions in an industry. In Turkmenistan, only automobiles and E&E receive negative impacts, but the remaining industries receive positive impacts. In Uzbekistan, agriculture and services receive positive impacts, but the sign of the percentage changes in the remaining industries differs among regions.

#### 4.2.4. CAREC Corridor 5

CAREC Corridor 5 connects the PRC and the Arabian Sea through the Kyrgyz Republic and Tajikistan. Corridor 501 connects Irkeshtam, in the Kyrgyz Republic, at the PRC border, and Panji Poyon, in Tajikistan, near the Afghanistan border through Dushanbe, the capital of Tajikistan. Corridor 503 also connects Irkeshtam, in the Kyrgyz Republic, at the PRC border, and Panji Poyon, in Tajikistan, near the Afghanistan border, through Dushanbe, the capital of Tajikistan. In this scenario, we suppose that the implementation and completion of the road and railway enhancement projects specified as CAREC Corridor 5 will take place in 2020.

Positive impacts are observable, but the magnitudes are smaller than for the other corridors. The positive impacts are relatively large in the regions in eastern Tajikistan. We find that the impacts of the project on each industry in terms of the percentage changes in the per capita real GDP differ among countries. In Armenia, only services receive negative impacts, but the impact on each industry in Tavush is slightly different from that in the other areas. In Azerbaijan, E&E and other manufacturing receive positive impacts, and services receive negative impacts. In Georgia, agriculture, automobiles, food, and other manufacturing receive positive impacts, and E&E and textiles receive negative impacts, but the sign of the percentage changes in mining differs among regions. In Kazakhstan, regions receive positive impacts in either food or services, and the region receives negative impacts in either food or services, but the remaining industries receive positive impacts. In the Kyrgyz Republic, positive impacts spread basically to all industries, but a few industries and regions receive negative impacts. In Tajikistan, other manufacturing receives negative impacts, but the signs of the impacts on the other industries differ among regions. In Turkmenistan and Uzbekistan, manufacturing industries receive positive impacts, but the sign of the percentage changes in the other industries differs among regions.

#### 4.2.5. CAREC Corridor 6

CAREC Corridor 6 connects the Russian Federation, the Caspian Sea, and the Arabian Sea through Kazakhstan, Turkmenistan, Uzbekistan, and Tajikistan. Corridor 601 connects Kurmangazy, in Kazakhstan, and Bukhara, in Uzbekistan. Corridor 602 connects Zhaisan, in Kazakhstan, at the Russian Federation border, and Termez, in Uzbekistan, through Tashkent, the capital city of Uzbekistan. Corridor 603 connects Zhaisan, in Kazakhstan, and Panji Poyon, in Tajikistan, through Tashkent, in Uzbekistan. Corridor 604 connects Kurmangazy, in Kazakhstan, and Etrek, in Turkmenistan. In this scenario, we suppose that the implementation and completion of the road and railway enhancement projects specified as CAREC Corridor 6 will occur in 2020.

Positive impacts are strongly observable along the corridor. The regions away from the corridor in Kazakhstan seem to suffer negative effects, albeit to a small degree. We find that the impacts of the project on each industry in terms of the percentage changes in the per capita real GDP differ among countries. Agriculture, textiles, food, other manufacturing, and mining receive positive impacts, and the remaining industries receive negative impacts in Armenia. Automobiles and other manufacturing receive positive impacts, but the signs of the percentage changes in each remaining industry differ among regions in Azerbaijan. Agriculture, automobiles, and textiles receive positive impacts, but the sign of the percentage changes in each remaining industry differs among regions in Georgia. Agriculture, E&E, and the food industry receive positive impacts, but the sign of the percentage changes in each remaining industry differs among regions in Kazakhstan. All the industries except mining receive positive impacts, but the sign of the percentage changes in mining differs among regions in

the Kyrgyz Republic. Agriculture, textiles, and services receive positive impacts, other manufacturing receives a negative impact, and the sign of the percentage changes in each remaining industry differs among regions in Tajikistan. Agriculture, textiles, and food receive positive impacts, but the sign of the percentage changes in mining differs among regions in Turkmenistan. Agriculture, textiles, and services receive positive impacts, food and other manufacturing receive negative impacts, and the sign of the percentage changes in each remaining industry differs among regions in Uzbekistan.

#### **4.2.6. All the CAREC Corridors**

In this scenario, we assume that the implementation of all of the CAREC corridors, 1, 2, 3, 5, and 6, takes place simultaneously and reaches completion by 2020. Although the magnitude of the economic impacts is not uniform, most regions seem to experience positive effects from the combination of all the CAREC corridors.

We find that the impacts of the combination of the projects on each industry in terms of the percentage changes in the per capita real GDP differ among countries. In Armenia, agriculture, textiles, food, and services receive positive impacts, other manufacturing and mining receive negative impacts, and the sign of the percentage changes in automobiles and E&E differs among regions. In Azerbaijan, E&E, textiles, and food receive positive impacts, other manufacturing receives negative impacts, and the sign of the percentage changes in each remaining industry differs among regions. In Georgia, agriculture, automobiles, and textiles receive positive impacts, food, other manufacturing, and mining receive negative impacts, and the sign of percentage changes in each remaining industry differs among regions. In Kazakhstan, services receive extremely positive impacts. In the Kyrgyz Republic and Tajikistan, services receive large positive impacts. In Turkmenistan, services receive large positive impacts in almost all areas, but other manufacturing receives large negative impacts. In Uzbekistan, services receive large positive impacts, but other manufacturing and mining receive negative impacts.

### **4.3 Economic Impacts of the CAREC Corridors and the TITR**

In this section, we discuss the economic impacts of the Trans-Caspian International Transport Route (TITR). We also examine the spillover effects and synergistic effects between the CAREC corridors and the TITR by comparing the impacts with those in the previous section.

The TITR is a logistics-oriented project stretching from the PRC, through Kazakhstan, the Caspian Sea, Azerbaijan, and Georgia to Turkey and European countries. As the map on the TITR web page shows, that the TITR is composed of railway links and shipping links connecting the PRC through Central Asia to Europe. In our analysis, we slightly modify the network by dropping European networks in Eastern Europe, such as Ukraine, Romania, and Poland.<sup>10</sup> As the previous sections discussed, railway networks in CAREC are developing as CAREC corridors. At the same time, as a subset of the larger transport networks, parts of the CAREC railway corridors appear within the TITR.

The railway links within our database cover Central Asia as well as most of the Asian countries and even include sea routes in the Caspian Sea, Black Sea, and Mediterranean Sea. Some parts of the TITR existed in 2010 or around 2013, but some are still missing links. In our simulation, we assume that all the networks are

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<sup>10</sup> <https://middlecorridor.com/en/route>.



operational in 2020. We obtain some important information on parameters from the field studies that Watanabe et al. (2021) conducted.

From our simulation results, we can confirm that regional impacts are widely observable across regions, including the regions that the TITR does not cross directly. This shows exactly the spillover effects in the transport networks. There are also some negatively affected regions in northeastern provinces in the PRC. We expect that, due to the relative increase in accessibility in the central and western regions of the PRC, the northeastern regions have lost their relative position and economic activities may have relocated.

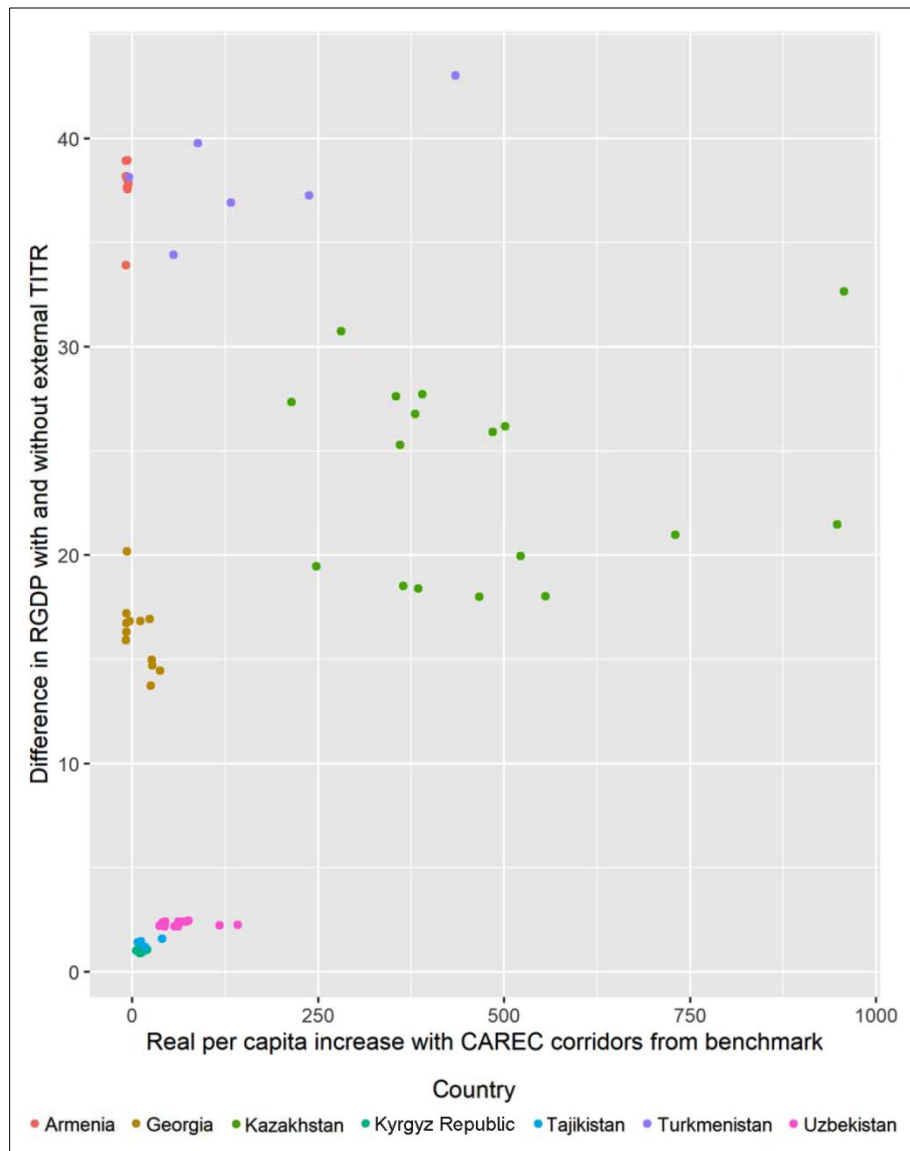
We conduct a further comparison between all the CAREC corridors and between all the CAREC corridors plus the TITR, which involves performing an analysis with and without external connections from Central Asia, specifically the corridor passing through Turkey and the PRC. Clear contrasts in the results are apparent in Turkey and in the PRC. As there were no specific connections in the scenario containing all the CAREC corridors, these two ends can enjoy direct benefits from the projects within their countries and indirect benefits from having a better connection to the European market (for the PRC) and to the Asian market (for Turkey).

A more detailed comparison of the two scenarios (CAREC corridors with and without external connectivity via the TITR) can show the synergy effects of the two sets of corridors, namely the CAREC and TITR corridors. Figure 3 shows the benefits of external links via the TITR on the Y-axis and the initial benefits of the CAREC corridors on the X-axis. The observations are regions in the CAREC countries. The higher the score on the vertical axis, the greater the benefits of having external linkages via the TITR. On the horizontal axis, when the observations are on the right side, it means that the benefits of having all the CAREC corridors (without the TITR, which we then compare with the benchmark) are larger. As is clear in the figure, regions in Kazakhstan show larger benefits from CAREC corridors and receive benefits from connecting via the TITR at the middle level of about \$20–30 per capita. On the other hand, Armenia and Turkmenistan show larger synergistic effects of the TITR. Georgian regions follow the first and second groups mentioned above. The rest of the regions are ranked lower and have smaller synergy effects.

A comparison of the scales of the Y-axis and X-axis shows that the direct impacts from the CAREC corridor (X-axis) are much larger than the synergy effects (Y-axis). Thus, for the growth of the CAREC regions, the improvements within their regions are also vital for their own growth. With the TITR corridors, we can confirm positive benefits for all the CAREC regions.

Regarding the industrial composition, the benefits largely arise in service sectors in terms of the percentage changes in the per capita real GDP. In Armenia, other manufacturing and services receive large positive impacts. In Azerbaijan, services receive large positive impacts in some regions and negative impacts in other regions. In Georgia, services receive large positive impacts in some regions. In Kazakhstan, services receive extremely large positive impacts, but other manufacturing receive large negative impacts. In the Kyrgyz Republic, services receive large positive impacts, but mining receives negative impacts. In Tajikistan, services receive large positive impacts, but other manufacturing receives negative impacts. In Turkmenistan, each region receives large positive impacts in either services or other manufacturing, but the regions receive negative impacts in either services or other manufacturing. In Uzbekistan, services receive large positive impacts, but other manufacturing and mining receive negative impacts.

**Figure 3: Comparison of Economic Impacts with and without the TITR  
(External Connectivity of CAREC Corridors)**



Notes: The figure shows the benefits of external links via the TITR on the Y-axis and the initial benefits of the CAREC corridors on the X-axis. Specifically, the Y-axis is the differential of the real GRDP per capita, which we obtained from the real GRDP per capita in the scenario with all the CAREC and TITR corridors. The X-axis is the increase in the real per capita GRDP with the implementation of the CAREC corridors from the benchmark case (without any projects).  
Source: Calculated by IDE-GSM.

For further discussion, we can consider the impacts on the neighboring countries, namely the PRC, Turkey, and the Russian Federation. Two forces are apparent from the analysis: the spillover effects of the CAREC corridors and the synergy effects of CAREC + TITR. Since there is no project in these countries, we can view any impacts from the CAREC corridors as spillover effects. Such impacts may be positive if regions are complementary or negative if regions are substitutive. The results show both types of regions in the three countries. However, the average spillover effects are positive in the PRC and slightly negative in Turkey and the Russian Federation. In terms of the synergistic effects of the TITR, highly positive impacts are evident in all of these countries. Specifically, the average impacts are around 330 for Turkey and

40 for the PRC, meaning that these countries can be ranked as the top two in the countries involved.

## 5. CONCLUSIONS

This study provides evaluations of the transport infrastructure projects of the Central Asia Regional Economic Cooperation Program (CAREC) and Trans-Caspian International Transport Route (TITR) corridors. Using our spatial CGE model of spatial economics with sub-national data, the following results are some of the extracts.

First, we find that economic impacts are not spatially limited to the regions that have implemented projects. This is because the improvements in parts of the transport networks can affect much broader spatial scopes. It is likely that population and industry will shift to regions with better connectivity by virtue of corridor development. The development of an economic corridor can benefit the regions away from corridors but does not necessarily benefit all the sub-national regions. Our results suggest that a combination of multiple corridors can provide balanced regional development. Further initiatives with complementary development programs would ensure stronger developments in multiple sectors and across wider regions.

Second, we confirm that the projects have produced spatially large impacts and transformed regional advantages. The CAREC corridors and the TITR tend to provide greater economic growth as a result of the positive economic impacts that the numerical analysis identified.

Third, the analysis reveals that the economic impacts of the projects are mainly observable in the service sector. This is because the current level of industrialization in the CWA countries is generally insufficient to benefit from corridor development. Further research should consider the establishment of Special Economic Zones (SEZs) and other industrial development policies alongside transport development projects.

To spread economic activities further by developing and improving new and existing infrastructures, the results show that it is better to connect a large city with railways rather than linking it with its hinterland. It will be straightforward to calculate the expected profits resulting from such linkages, and a priori we can expect the link to strengthen the relative importance of the large city. The drawback of building railroads only in the hinterlands lies in the difficulty of predicting whether the new infrastructure will lower the transport costs enough to bring new industries to the periphery.

There is still some room to improve the analysis. First, it is always desirable to have more reliable economic data at the sub-national level, such as the GRDP by industry. We attempted to compile those series in this study but the unavailability or non-existence of official national data impeded us. We should point out that the lack of manufacturing surveys prevented us from analyzing industrial clusters. Second, it is better to have reliable non-economic data on international connectivity, such as customs clearance, waiting times, loading and unloading times, and others. Each border crossing point will have very different facilities and other conditions. Precise data would allow us to examine the impacts of efforts for regional integration. These are particularly important for landlocked countries like those in CWA.

As a caveat, it is worth noting that the model that we used cannot accommodate cultural, social, environmental, and other aspects, which may be of importance to the lives of the people in the region. It also ignores diversity and heterogeneity of

preferences, situations, and wealth. Thus, by combining any factors in a plausible manner, the impacts of certain scenarios may have different results for some groups of people and regions. It is necessary to pay particular attention to the distribution of positive economic benefits. In addition, in 2021, we do not fully understand the impacts of COVID-19, and our analysis did not incorporate such uncertain shocks. Kumagai et al. (2020) attempted to explore the impacts of COVID-19 using the same model, finding negative impacts on economic growth all over the world. Bearing this in mind, we can point out possible overestimation in the simulation results in this study. However, the spatial relationships among the large markets and road networks are the same, and the predicted distributions of spatial impacts will be similar.

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