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Economic Impacts of the blockage of the Suez Canal: an Analysis by IDE-GSM

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Abstract

In this study, we attempted to identify the magnitude and geographical distribution of the negative and positive economic impacts of the blockage of the Suez Canal using a CGE model based on spatial economics with realistic geographical/logistic settings at the sub-national level. The estimated annual net negative impacts of the blockage totaled 79.6 billion USD for the world or 0.1% of the world's GDP. However, positive impacts (211.9 billion USD) offset the significant negative impacts (291.5 billion USD). Among the countries, China is negatively affected most by the blockage of the Suez Canal in terms of value (-73.0 billion USD), followed by India (-26.2 billion USD) and Israel (-20.4 billion USD). EU also has a sizeable negative impact (-72.9 billion USD) collectively. However, some countries benefited from the blockage, such as the US (59.9 billion USD), Japan (32.0 billion USD), Brazil (20.0 billion USD) and Australia (18.2 billion USD). We effectively showed that the blockage of just one point in the sea route has a substantial adverse economic impact worldwide.

Keywords: Suez Canal, IDE-GSM

JEL classification: C68, F13

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1. Introduction

On March 23, 2021, the container vessel Ever Given ran aground in the Suez Canal and blocked one of the most critical canals in the world for six days. This accident disturbed international supply chains because the canal was one of the world's choke points of sea lanes. Consequently, some ships sailed from the Indian Ocean to the Mediterranean via an old route around the Cape of Good Hope. This accident reaffirmed the importance of the canal in the global economy.

In addition, since November 2023, attacks on vessels by the Yemeni rebel Houthis intensified in the Red Sea and Gulf of Aden, which serve as entrances to the Suez Canal from the Asian side. The attacks on vessels by the Houthis are intended to show solidarity with Hamas in the conflict in the Gaza Strip, which began with an attack on Israel by the Gaza-based Islamic organization Hamas on October 7, 2023. These attacks on vessels prevented safe passage through and consequently blocked the Suez Canal. Thus, many vessels chose to use the route around the Cape of Good Hope.

This study aimed to estimate the economic impacts of the blockage of the Suez Canal using a general equilibrium simulation model called the IDE-GSM (Geographical Simulation Model developed by IDE-JETRO). Generally, evaluating the economic impact of a canal heavily used by numerous routes connecting various origin-destination combinations is challenging. The IDE-GSM enables this estimation by blocking the path through the Suez Canal, as the actual situation is caused by an accident or attack. The model automatically calculates the optimal routes for every origin-destination-industry combination under modified routes, thereby providing new transport costs. These economic impacts spread to regions worldwide, changing the distribution of workers among regions and the structure of industries in each region owing to various centrifugal and centripetal forces in spatial economics. Consequently, the Suez Canal's blockage affected each region's gross domestic product (GDP).

The advantages of the IDE-GSM can be summarized as follows: subnational economic geography, multimodal logistics networks, and agglomeration economies. First, our data were constructed at a subnational level, such as district/prefecture/province, and eight industrial classifications. With such detailed data on economic geography, economic impacts can be obtained at the sub-national level by industry. Second, our model incorporates multimodal logistics networks such as roads, railways, ships, and air. The impact of blockages is transmitted through multimodal logistics networks. As a result, some regions may experience negative impacts from the blockage, whereas others may not. Third, the IDE-GSM incorporates an economic model of spatial economics to estimate the changes in the distribution of industries and population brought about by the blockage.

The remainder of this paper is organized as follows. Section 2 presents a brief literature review of the history of the Suez Canal and its economic impact. Section 3 describes the scenario for calculating the economic impact of the canal. The results estimated using our simulation model are presented in section 4. The final section concludes the paper with a summary of policy implications. In the Appendix, we briefly introduce the economic model of the IDE-GSM and explain its parameters.

2. Literature review

The Suez Canal, the world's busiest canal connecting the Mediterranean and Red Seas through the Suez isthmus, opened in 1869. The canal realized a route linking Asia and Europe without going around Africa, shortening it by approximately 9,000 km. Currently, about 18,000 vessels pass through the canals annually. The economic impact of the Suez Canal was significant. However, virtually no studies have estimated the economic impacts of the Canal as a number, like an increase in the world GDP.

Some studies have been conducted on the Suez Canal. One type of literature examines the profitability of alternative routes compared with that of the Suez Canal. Zhang et al. (2016) compared the Northern Sea Route as an alternative to the path through the Suez Canal and concluded that the new route was unsuitable for container shipping between Europe and Asia. Notteboom (2012) found 11 feasible routes via the Cape of Good Hope as alternatives to the Suez Canal.

Another strand of the literature uses the closure of the Suez Canal between 1967 and 1975 as a consequence of the Six-Day War as a natural experiment on trade distances. Gerritse (2021) examines if the increase in trade costs makes developing countries specialize in production that does not require contract enforcement and finds that this kind of “detrimental specialization” does not occur. Feyer (2021) examined the relationship between distance, trade, and income using the closure of the Suez Canal as a natural experiment using econometric methods and obtained some positive coefficients among these three variables.

However, we could not find literature that directly estimated the worldwide economic impacts, in terms of GDP, of the opening or closure of the Canal on the geographical distribution of economic activities. This is simply because no good economic model combines realistic logistic networks with the computable general equilibrium (CGE)-type economic model covering the world at the subnational level. The IDE-GSM is precisely this type of economic model. Thus, the economic effects of the blockage of the Suez Canal can be calculated using a straightforward procedure in the IDE-GSM.

3. Scenarios

To estimate the economic impacts of the Suez Canal blockage, we run the simulation twice; one is on the baseline scenario in which the Suez Canal opens to traffic, and the other is an alternative scenario in which the Suez Canal is blocked. We compared the regional GDPs for each scenario and considered the differences between the values obtained from the two simulations as the economic impacts of the Suez Canal blockage (Figure 1).

<<Insert Figure 1 about here>>

In the baseline scenario, we assumed a business-as-usual situation. The following assumptions were made in all scenarios, including the baseline case, even if they were not specified in the following scenarios:

- Each country's national population is assumed to increase at the rate the United Nations Population Division forecasted until 2030.
- International labor migration is prohibited.
- Tariffs, non-tariff barriers, and service barriers change according to the free trade agreements (FTAs) and economic partnership agreements (EPAs) currently in effect and according to the phased-in tariff reduction schedule of the FTAs/EPAs.
- We provide different exogenous growth rates for each country's technological parameters to replicate the GDP growth trend from 2015 to 2026 as estimated and provided in the World Economic Outlook April 2021 by the International Monetary Fund.
- After 2026, we gradually reduced the calibrated growth rates of the technological parameters by half over 20 years.

For the alternative scenario, all the assumptions were retained, except for the sea route through the Suez Canal being blocked in 2021 for one year. Thus, the estimated economic impact of the blockage is 2021, and the results are annual. In this blockage scenario, the regional GDPs of many regions are expected to be lower than in the baseline scenario.

One of the features of the IDE-GSM is the automatic recalculation of minimum-cost routes for each origin-destination pair by industry. The blockage of the Suez Canal does not simply mean that all sea routes through the canal are superseded by routes detoured via the Cape of Good Hope. Some origin-destination-industry combinations utilize the Trans-Sevillian railways, while others use the land route between Port Said and Port Suez. This depends on the alternative route suggested by the multimodal minimum cost calculations in the model.

The IDE-GSM calculates the broader economic impacts of blockages in each country/region. The negative economic impacts first spread as increased trade costs for the origin-destination-industry combinations that formerly pass through the canal in the baseline scenario, based on automatically recalculated optimal routes inside the model, given the blockage of the Suez Canal. Increased trade costs lead to higher prices and lower demand for goods, thus lowering the nominal wage for workers in some regions/industries in which economic activities rely on the canal as direct impacts. As a result, workers may relocate to industries or regions to provide higher nominal wages as indirect impacts. These changes in the critical variables for each region/industry interact through the mechanism of spatial economics.

4. Simulation Results

Table 1 shows the economic impacts of the Suez Canal blockage by country and region in terms of GDP. The blockage's estimated annual net negative impacts totaled 79.6 billion USD for the world, or 0.1% of the world's GDP. However, more significant negative impacts (291.5 billion USD) were offset by positive impacts (211.9 billion). In other words, larger negative impacts in some countries are offset by positive impacts in others.

The canal’s westbound traffic is roughly 5.1 billion USD daily, and eastbound traffic is around 4.5 billion USD daily, based on Lloyd’s list value (LaRocco, 2021). Foreign Affairs and Trade, New Zealand, reported that the daily traffic through the Suez Canal comprises 50 ships carrying an average of 3–9 billion USD of cargo (Foreign Affairs and Trade, New Zealand, 2012). Thus, Ever Given held up 125–400 million USD per hour in trade by dividing two-way traffic by 24 hours. The simulated traffic value through the Suez Canal in the IDE-GSM was approximately 1468 billion USD a year or 4 billion USD daily, in line with the previously reported value.

Compared to the estimated value of holding up per day, the negative impact obtained from the IDE-GSM is small. This is because alternate routes are used instead of waiting around the canal. However, a negative impact emerges because of the longer transport distances and longer transport hours, which provide higher prices for goods and reduce demand.

The countries most affected by the Suez Canal were China (-73.0 billion USD), followed by India (-26.2 billion USD), and Israel (-20.4 billion USD). Notably, the EU was substantially affected (-72.9 billion USD). For aggregated regions, Western Europe (-68.1 billion USD) lost from the blockage most, followed by East Asia (-55.3 billion USD), South Asia (-33.4 billion USD), and Southeast Asia (-28.0 billion USD). By industry, other manufacturing (-87.4 billion USD) loses the most, followed by mining (-38.3 billion USD), agriculture (-36.8 billion USD), and services (-11.4 billion USD). This result supports that “the canal has long been the primary route for fuel, both from the Gulf States bound for Europe and Russia, via Crimea, to East Asia. This is crucial for distributing manufactured goods from China to Europe” (Kelso, 2021).

Conversely, the countries that gained the most from the blockage are the US (59.9 billion USD), followed by Japan (32.0 billion USD), Brazil (20.0 billion USD), and Australia (18.2 billion USD). For aggregated regions, North America (59.4 billion USD) gains the most from the blockage, followed by South America (37.5 billion USD) and Oceania (20.4 billion USD). By industry, food processing (87.5 billion USD) gains the most, followed by E&E (5.7 billion USD) and the automotive industry (0.6 billion USD).

Dividing the global economy into Europe, Asia, and America, countries in the American category can benefit from the blockage, but the remaining two areas suffer from it. The blockage creates effects such that countries in the category of America are regarded as a kind of "hub" in the global economy. Blockage increases the price of the goods to be passed through the canal, which decreases not only the demand for those goods but also milder price competition among firms. Thus, countries that do not depend on the canal benefit from the block, and the boundary of the category between Asia and America seems to exist between Japan and China. Japan is an Asian country but relies more on trade with the US than Europe. In contrast, China depends more on trade with Europe than the US.

Table 2 shows the economic impacts of the blockage of the canal by country and region in terms of GDP percentage. The negative economic impact of the blockages totaled 0.1% of the world's GDP. The country that was damaged most by the blockage of the Suez Canal is Israel (-6.0%), followed by Sudan (-4.6%), Ethiopia (-4.3%) and Jordan (-3.4%). For aggregated regions, Eastern Africa (-2.7%) loses from the blockage most, followed by the Mediterranean Sea (-2.0%), Southeast Asia (-0.9%) and South Asia (-0.7%). By industry, agriculture (-1.4%) loses the most, followed by mining (-1.2%) and other manufacturing (-0.7%). The distance to the canal matter was then determined.

The countries that have benefited the most from the blockage of the Suez Canal are Swaziland (4.8%), followed by Yemen (2.0%), Uruguay (1.9%), and Egypt (1.8%)[1]. Among aggregated regions, Oceania (1.1%) gains the most from the blockage, followed by Southern Africa (1.0 %) and South America (0.9%). Food processing (3.7%) received the most by industry, followed by E&E (0.3%).

Figure 2 shows the geographic distribution of the economic impacts of the Suez Canal blockage in terms of impact density, defined as the economic impact in value for a region divided by the region's area (thousand USD/km2). The regions most damaged by the blockage were Europe, including Scandinavia, regions around the Mediterranean Sea, India, Southeast Asia, China, and South Korea. Notably, not all regions of China suffered from the blockage. A few regions in China experienced a positive impact, showing the analysis's importance based on finer geographic divisions.

[1] The loss from the fee from Suez Canal is not considered in this simulation.

However, several regions in North and South America, Southern Africa, Russia, Central Asia, Japan, Oceania, and the Middle East have gained from the blockage because these regions did not benefit much from the Suez Canal from the beginning or substitute trade between Europe and Asia through the Suez Canal, making these regions advantageous compared with other regions affected by the blockage.

Figure 3 shows the geographic distribution of the economic impacts of the blockage of the Suez Canal as a percentage of GDP. Europe and the coastal regions of China, Southeast Asia, India, and Northern and Western and Eastern Africa have negative impacts from the blockage. However, the blockage affected some regions in Russia, Japan, the Middle East, Southern Africa, Oceania, and North and South America.

Table 3 shows the top ten regions that are damaged by the blockage of the Suez Canal. Tel Aviv (representing the entire Israeli region) was most damaged by the blockage, followed by Shanghai, China, and Singapore. Surprisingly, the top ten regions come from seven countries worldwide, indicating that the Suez Canal is relevant to many countries.

Table 4 shows the top ten regions that benefited from the blockage of the Canal. The region that benefited most from the blockage was Rio de Janeiro (which represents the whole region in Brazil), followed by California, the United States, and Tokyo, Japan.

4. Conclusions

This study attempted to identify the magnitude and geographical distribution of the economic impacts of the Suez Canal blockage using a CGE model based on spatial economics. The estimated annual negative impacts of the blockage totaled 79.7 billion USD for the world or 0.1% of the world's GDP, although more significant negative impacts (291.5 billion USD) are offset by positive impacts (211.9 billion)

Among these countries, China was most negatively affected by the blockage of the Suez Canal in terms of value, although some regions in China enjoyed positive impacts. Therefore, it is understandable that China has invested heavily in the land part of the Belt and Road Initiative, which connects China and Europe by train, considering that there is another chokepoint on the sea route between China and Europe: the Strait of Malacca. It should also be noted that the blockage of the Suez Canal had a negative economic impact on Israel. Considering these effects, armed groups may continue to attack ships passing through the Canal as the conflict over Palestine intensifies.

Surprisingly, the economic impacts of the blockage are widespread, such as in Europe, Africa, North America, and South, Southeast, and East Asia. In addition, we revealed that a small number of regions gained from the blockage, which is a unique feature of the IDE-GSM that considers the changes in relative locational advantages according to modified logistic networks, mainly caused by the higher traffic costs between Europe and Asia. We effectively showed that the blockage of just one point on the sea route has a substantial adverse economic impact worldwide. This type of estimation is impossible without a model such as the IDE-GSM, which is based on spatial economics and incorporates realistic geographical/logistic settings at the sub-national level.

References

Dixit and Stiglitz (1977) Monopolistic competition and optimum product variety. *American Economic Review* **67**(3), 297-308.

Feyrer, J. (2021). Distance, trade, and income — The 1967 to 1975 closing of the Suez canal as a natural experiment. *Journal of Development Economics* **153**, 102708.

Fujita, M., P. Krugman, and A. J. Venables (1999) *The spatial economics: Cities, regions and international trade* Cambridge, MIT Press.

Gerritse, M. (2021). Does trade cause detrimental specialization in developing economies? Evidence from countries south of the Suez Canal. *Journal of Development Economics* **152**, 102676.

Hayakawa, K. and F. Kimura. 2015. "How Much Do Free Trade Agreements Reduce Impediments to Trade?" *Open Economies Review* 26(4):711-729.

Hummels, D. L. (1999). Toward a geography of trade costs. *Available at SSRN 160533*.

Head, K., and Mayer, T. (2000). Non-Europe: the magnitude and causes of market fragmentation in the EU. *Review of World Economics*, *136*(2), 284-314.

JETRO. (2013). Survey of Japanese Companies in Asia and Oceania (Zai Azia-Osearia Nikkei Kigyo Jittai Chosa)

Kelso, P. (2021, March 31) "Suez Canal blocked: What the mishap in one of the busiest shipping lanes means for the world" Sky news, https://news.sky.com/story/why-the-cost-of-suez-canal-mishap-is-being-calculated-around-the-world-12255715

Kumagai, S., K. Hayakawa, I. Isono, Keola S., and K. Tsubota (2013), Geographical Simulation Analysis for Logistics Enhancement in Asia, *Economic Modelling*, 34, 145-153.

Kumagai, S. and I. Isono (2022), Geographical Simulation Analysis, in Kimura, F. and K. Oikawa (ed.), *The Comprehensive Asia Development Plan (CADP) 3.0: Towards an Integrated, Innovative, Inclusive, and Sustainable Economy*, 212-233, Economic Research Institute for ASEAN and East Asia (ERIA).
https://www.eria.org/uploads/media/Books/2022-CADP-3/11_ch.7-Geographical-Simulation-Analysis.pdf

LaRocco, L. A. (2021, March 25) "Suez Canal blockage is delaying an estimated $400 million an hour in goods" CNBC. https://www.cnbc.com/2021/03/25/suez-canal-blockage-is-delaying-an-estimated-400-million-an-hour-in-goods.html

Foreign Affairs and Trade, New Zealand (2021, April 18) "The Importance of the Suez Canal to Global Trade." https://www.mfat.govt.nz/en/trade/mfat-market-reports/market-reports-middle-east/the-importance-of-the-suez-canal-to-global-trade-18-april-2021

Notteboom, T. E. (2012). Towards a new intermediate hub region in container shipping? Relay and interlining via the Cape route vs. the Suez route. *J Transp Geogr* **22**, 164–178.

Zhang, Y., Meng, Q., and Ng, S. H. (2016). Shipping efficiency comparison between Northern Sea Route and the conventional Asia-Europe shipping route via Suez Canal. *Journal of Transport Geography*, *57*, 241-249.

Appendix

A.1 Data set

For the simulation analysis, we constructed an economic dataset at the subnational level (See Kumagai and Isono 2022 for more details). The dataset covers 169 countries/economies and 3,265 subnational regions. We constructed regional-level GDP (Regional GDP) data for the agricultural sector, mining sector, five manufacturing subsectors, and the service sector for 2015, primarily based on official statistics of the respective countries. The five manufacturing subsectors were food processing, garments and textiles, electronics and electricity (E&E), automotive, and other manufacturing. Typically, we use national and regional GDP data with industrial surveys/censuses to divide the GRDP into finer subsectors if the country lacks GDP data by subnational region and industry.

For the transport network data, the number of routes included in the dataset used in the simulation is 20,212 (land: 13,009; sea and inland waterways: 1,317; air: 2,672; railway: 3,139; and high-speed railway:75). The route data consisted of start cities, end cities, distances between cities, and the quality of the route, represented by the speed of the vehicle running on the route.

A.2 Economic model

The structure of the economic model in the IDE-GSM is closely related to that described in Chapter 16 of Fujita, Krugman and Venables (1999). That is, our model is based on Dixit and Stiglitz (1977). However, the model was adjusted for consistency with the dataset. More precisely, the agricultural and mining sectors are elaborated in our model. Furthermore, the industry selection of workers among the eight industries and the location choice of labor among the regions in a country are allowed.

The numbers of regions and countries are provided by the data. To specify industry k, we, respectively, express agriculture; mining; automotive; E&E; garments and textiles; food processing; other manufacturing; and services as k=1, 2, 3, …, 8 in the following equations. Each consumer is endowed with a unit of labor and other units of land. The amount of land in a region is given and distributed equally among the population of the region. The exogenous share of land in production is set for agriculture, and the remaining share is for mining.

Consumer Behavior

Every consumer shares the same Cobb-Douglas taste for the eight composite indices for consumption: agriculture, mining, automotive, electronics, textiles, food, other manufacturing, and services. Each industry's composite index is a sub-utility function defined over the varieties of goods in each industry and is defined by a constant elasticity of substitution (CES) function. The consumption of each variety in a type of index is determined by minimizing expenditure on the variety subject to the CES function. The price index of the composite index is defined such that the expenditure on the varieties is equivalent to the product of the price index and the amount of the composite index. The composite index is obtained by maximizing the utility subject to budget constraints. Income is the sum of wage income and land rent used only to pay for eight types of goods. Substituting the derived amounts of the composite index for a type into the derived consumption of each variety in the type yields the demand for a variety of the type.

We assume the iceberg transport technology. The amount produced at the gate of a factory is the transport cost multiplied by the demand of consumers and firms. The amount produced exceeds the demand of consumers and firms that melt away during transportation. The delivered price becomes the mill price multiplied by transport costs.

Production

We assume that all products are used for final consumption and as intermediate inputs. Labor is used in all industries. However, the land is used for agriculture and mining. These eight industries are divided into primary industries: agriculture and mining and the remaining industries. We assume that primary industries use constant returns to scale technology under perfect competition and that firms in the remaining industries use increasing returns to scale technology under monopolistic competition. Applying the Armington assumption, a product in a region in an industry of the primary industry and products in the industry from different regions are imperfect substitutes. The product of each firm in the manufacturing and service industries are differentiated in one of eight industries.

The production function of the agricultural or mining sector is a Cobb–Douglas function, given as

$$f(i,k) = A(i,k)L(i,k)^{\alpha_k}F(i,k)^{1-\alpha_k-\sum_{l=1}^{8}\alpha_{kl}}\prod_{l=1}^{8}N(i,l,k)^{\alpha_{kl}}, \quad k = 1,2$$

where $f(i,k)$ expresses the amount of production of industry k at location i, $A(i,k)$ the total factor productivity (TFP) of industry k at location i, $L(i,k)$ labor inputs for industry k at location i, $F(i,k)$ land input for industry k at location i, $N(i,l)$ intermediate inputs for location i provided by industry l. Note that industry l may not be the same as industry k. Furthermore, $\alpha_k \in (0,1)$ and $\alpha_{kl} \in (0,1)$ are, respectively, the input share of labor and intermediate inputs produced by industry l for industry k. We assume the positive share of land input, $1 - \alpha_k - \sum_{l=1}^{8}\alpha_{kl} > 0$.

Maximizing the profit of industry k, k=1, 2, locating at i with respect to labor input yields nominal wage rate for industry k at location i, $w(i,k)$, as follows:

$$w(i,k) = \alpha_k \frac{f(i,k)}{L(i,k)} p(i,k), \quad k = 1,2$$

where $p(i,k)$ expresses the price of a good produced in industry k at location i. Maximizing the profit of industry k, k=1, 2, at location i with respect to an intermediate input yields the amount of intermediate inputs provided by industry l for use in industry k at location i, $N(i,l,k)$, as follows:

$$N(i,l,k) = \alpha_{kl} \frac{f(i,k)}{G(i,l)} p(i,k), \qquad k = 1,2.$$

Using the zero-profit condition in agriculture and mining industries at location i, the budget constraint of a representative consumer at location i is obtained as follows:

$$\mathrm{Y}(i) = \sum_{k=1}^{2}\left(p(i,k)f(i,k) - \sum_{l=1}^{8} G(i,l)N(i,l,k)\right) + \sum_{k=3}^{8} \mathrm{w}(i,k)L(i,k)$$

The price index of the goods in industry 1 or 2 at location i, $G(i,k)$, is defined as follows:

$$G(i,k) = \left(\sum_{j=1}^{R} p(i,k)^{-(\sigma_k-1)} T_{ji}^{k\;-(\sigma_k-1)}\right)^{-\frac{1}{\sigma_k-1}}, \quad k = 1,2$$

where σ_k>1 shows the elasticity of substitution between any varieties of goods in industry k, and T_{ji}^k transport costs for shipping goods in industry k from location j to location i. We assume $T_{ji}^k > 1$ if $j \neq i$ and $T_{ji}^k = 1$ if $j = i$. In other words, transportation within the same region is costless.

Firms in the manufacturing and service sectors use an input composite expressed by a Cobb-Douglass function of labor and intermediate goods. The input composite is used in the fixed cost and the marginal cost of a firm. We choose units such that the marginal input requirement equals the price-cost markup. Profit maximization yields the price of the variety produced by a firm in industry k and location i, $p(i,k)$, as follows:

$$p(i,k) = \frac{w(i,k)^{1-\sum_{l=1}^{8}\beta_{kl}} \prod_{l=1}^{8} G(i,k)^{\beta_{kl}}}{A(i,k)}, \quad k = 3, 4, 5, \ldots, \quad 8$$

where $A(i,k)$ is the total factor productivity of industry k at location i, and $\beta_{kl} \in (0,1)$ intermediate share provided by industry l for industry k. We assume the positive share of labor input, $1 - \sum_{l=1}^{8}\beta_{kl} > 0$.

Let the number of firms in industry k at location i be $n(i,k)$, the output of each firm in industry k at location i $q(i,k)$, and number of workers in industry k at location i $L(i,k)$. The total value of output in industry k at location i is $n(i,k)p(i,k)q(i,k)$. Thus, the wage bill in industry k at location i, $w(i,k)L(i,k)$, is a share $1 - \sum_{l=1}^{8}\beta_{kl}$ of $n(i,k)p(i,k)q(i,k)$. We choose units such that $q(i,k) = 1 - \sum_{l=1}^{8}\beta_{kl}$, so that we obtain $n(i,k) = w(i,k)L(i,k)/p(i,k)$. Since the price index of industry k=3, 4, 5, …, 8 is defined as $G(i,k)^{-\sigma_k - 1} = \sum_{j=1}^{R} n(i,k)p(i,k)^{-(\sigma_k-1)} T_{ji}^{k^{-(\sigma_k-1)}}$, we obtain:

$$G(i,k) = \left\{ \sum_{j=1}^{R} L(j,k)A(j,k)^{\sigma_k} w(j,k)^{1-\sigma_k\left(1-\sum_{l=1}^{8}\beta_{kl}\right)} T_{ji}^{k^{-(\sigma_k-1)}} \prod_{l=1}^{8} G(j,l)^{-\sigma_k\beta_{kl}} \right\}^{-\frac{1}{\sigma_k - 1}},$$

$k = 3, 4, 5, \ldots, 8.$

The output of industry k is consumed as the final product and used as an intermediate input. The amount consumed as final products is $\mu_k Y(i)$. The quantity used as intermediate inputs by industry l=1, 2 is $\alpha_{lk} p(i,k) f(i,k)$, and that by industry l=3, 4, 5, 6, 7, 8 is $\beta_{lk} n(i,l)p(i,l)q(i,l)$. Using the constant share of wage payment in sales, we obtain expenditure on industry k at location i, $E(i,k)$, as follows:

$$E(i,k) = \mu_k \mathrm{Y}(i) + \sum_{l=3}^{8} \frac{\beta_{lk}}{1-\sum_{k=1}^{8}\beta_{lk}} \mathrm{w}(i,l)L(i,l) + \sum_{l=1}^{2} \frac{\alpha_{lk}}{\alpha_l} \mathrm{w}(i,l)L(i,l).$$

Rewriting the market-clearing condition for a good produced by the agricultural or mining sector at location i yields

$$p(i,k) = \left[\sum_{j=1}^{R} E(j,k) T_{ij}^{k\,-(\sigma_k-1)} G_A(j,k)^{\sigma_k-1} / f(i,k)\right]^{\frac{1}{\sigma_k}}, \quad k = 1, 2.$$

Rewriting the market-clearing condition for a good produced by one of the manufacturing and service sectors at location i yields the nominal wage rate of industry k in location i as follows:

$$w(i,k) = \left\{ \frac{A(i,k)(1-\sum_{l=1}^{8}\beta_{kl})^{\frac{1}{\sigma_k}} \left[\sum_{j=1}^{R} E(j,k) T_{ij}^{k\,-(\sigma_k-1)} G(j,k)^{\sigma_k-1}\right]^{\frac{1}{\sigma_k}}}{\prod_{l=1}^{8} G(i,l)^{\beta_{kl}}} \right\}^{\frac{1}{1-\sum_{l=1}^{8}\beta_{kl}}}, \qquad k = 3,$$

$4, 5, \ldots, 8.$

Now, given the number of workers in each industry and location, we have all equations to determine all endogenous variables: nominal wage rate for each industry and each location, the price of goods for each industry and each location, the price index for each industry and each location, expenditure on an industry in each location, income in each location, the amount of intermediate inputs for the agriculture or mining sector in each location, and the final production of the agriculture or mining sector in each location. In this Appendix, these endogenous variables are expressed on the left-hand sides of the equations. It is worth to note that the level of TFP is not determined as the endogenous variable of this economic model but is determined from this economic model by assuming that the economy is in equilibrium at the initial stage of values in the dataset we collected.

Furthermore, we determine the number of workers in each industry and location using two replicator equations: First, the rate of change of the share of workers for industry k in location i with respect to time, $\dot{\lambda}_k(i)$, is given by the following equation:

$$\dot{\lambda}_k(i) = \gamma_k \left(\frac{\omega_k(i)}{\overline{\omega}(i)} - 1 \right) \lambda_k(i)$$

where $\lambda_k(i)$ shows the share of workers for industry k in location i, $\omega_k(i)$ the real wage rate in industry k and location i, $\overline{\omega}(i)$ the average real wage rate in location i and γ_k a positive parameter for industry k. Note that the revenue from land in location i is expressed as $\sum_{k=1}^{2} \frac{1-\alpha_k-\sum_{l=1}^{8}\alpha_{kl}}{\alpha_k} w(i,k)\, L(i,k)$. Thus, the real wage rate in industry k and location i is obtained as

$$\omega_k(i) = \frac{w(i,k) + \left(\sum_{k=1}^{2} \frac{1-\alpha_k-\sum_{l=1}^{8}\alpha_{kl}}{\alpha_k} w(i,k)\, L(i,k) \right) / \sum_{k=1}^{8} L(i,k)}{\prod_{l=1}^{8} G(i,l)^{\mu_k}}.$$

This replicator equation determines the job selection of workers from one industry to another at a given location.

The rate of change of the share of workers for location i with respect to time, $\dot{\lambda}_L(\mathrm{i})$, is given by

$$\dot{\lambda}_L(\mathrm{i}) = \gamma_L \left(\frac{\omega(i)}{\overline{\omega}_C(i)} - 1 \right) \lambda_L(i)$$

where $\lambda_L(i)$ is the share of workers in location i, $\omega(i)$ the average real wage rate at location i, $\overline{\omega}_C(i)$ the average real wage rate of the country to which location i belongs, and γ_L a positive constant. The average real wage rate in location i, $\omega(i)$, is given by

$$\omega(i) = \frac{Y(i) / \sum_{k=1}^{8} L_k(i)}{\prod_{k=1}^{8} G(i,k)^{\mu_k}} = \overline{\omega}(i).$$

This replicator equation determines the relocation of workers from one location to another in a country.

A.3. Parameters

Transport costs in IDE-GSM (Figure A1) capture many factors.

<<Insert Figure A1 here>>

The sum of Tariffs and Non-Tariff Barriers (TNTBs) is estimated using the log-odds ratio approach initiated by Head and Mayer (2000). We estimated the industry-level TNTBs for 69 countries. The TNTBs for the remaining sampled countries were obtained by prorating their TNTBs according to their per capita GDP. To evaluate these estimates for TNTBs, we need elasticity of substitution, the sources of which are explained below.

Next, we obtain the NTBs by subtracting the tariff rates from the TNTBs. Our data source for tariff rates is the World Integrated Trade Solution, particularly Trade Analysis and Information System (TRAINS) raw data. For each trading pair, we aggregate the lowest tariff rates among all available tariff schemes at the six-digit level of a harmonized system into single tariff rates for each industry using a simple average. Available tariff schemes include most favoured nation, multilateral and bilateral FTAs and other schemes, such as the Generalized System of Preferences. Additionally, we take into account the tariff schedule in six ASEAN + 1 FTA, the Regional Comprehensive Economic Partnership, and the Comprehensive and Progressive Agreement for Trans-Pacific Partnership. Thus, we obtained different (bilateral) tariff rates and (importer-specific) NTBs by industry on a tariff-equivalent basis. Finally, our total transport costs are the product of the sum of physical transport and time costs and the sum of tariff rates and NTBs.

The industry-specific parameters are presented in Table A1. We adopted the elasticity of substitution for manufacturing sectors from Hummels (1999) and estimated it for services. Estimates of the elasticity of services are obtained by estimating the usual gravity equations for trade services, including independent variables such as the importer's GDP, exporter's GDP, importer's corporate tax, geographical distance between countries, a dummy for FTAs, a linguistic commonality dummy, and a colonial dummy. For this estimation, we employ data from the "Organization for Economic Cooperation and Development Statistics on International Trade in Services." We infer the elasticity of services using the coefficient for the corporate tax.

The consumption share of consumers by industry is determined uniformly for the entire region of the model. Changing the share per country or region would be more realistic; however, this cannot be achieved because we lack reliable consumption data. The single labor input share for each industry was uniformly applied throughout the region and period in the model. Although it may differ among countries/regions and across time, we use an “average” value; in this case, the value for Thailand, a country that is in the middle stage of economic development and whose value is taken from the Asian International Input-Output Table for 2005 by the IDE-JETRO. For the manufacturing sector, we used the data collected in the survey conducted by JETRO (2013).

Table 1: Economic impacts of the Suez Canal (million USD)

	Agriculture	Automotive	E&E	Textile	Food Proc.	Oth. Mfg.	Services	Mining	Real GDP
Indonesia	-3,544	-137	308	-948	1,355	447	-5,079	-5,281	-12,878
Malaysia	-187	-116	182	-308	167	-1,492	-3,785	-6,008	-11,547
Singapore	-93	-272	-6	-92	-93	-2,283	-3,561	-246	-6,645
Thailand	-405	-458	189	-719	820	-397	-177	-102	-1,248
Philippines	-306	9	104	-16	2,054	190	969	98	3,101
Vietnam	-192	1	55	-406	611	-190	290	802	971
Japan	-268	745	749	105	10,076	-5,847	26,542	-104	31,999
Korea	-297	-9	107	71	1,736	-6,273	-11,626	-1,079	-17,369
China	-5,142	191	2,667	5,406	36,306	-38,732	-33,634	-40,108	-73,046
Australia	-204	-23	22	-21	1,379	333	9,342	7,388	18,216
Taiwan	-87	-13	190	78	611	-246	1,849	27	2,408
India	-7,310	-43	271	-1,516	6,472	-6,539	-14,534	-2,997	-26,196
Sri Lanka	-261	-6	0	-786	-158	-122	-1,360	-12	-2,705
Swaziland	2	0	0	0	164	0	61	0	228
Yemen	-8	0	0	0	10	6	163	190	361
Uruguay	-19	1	1	5	557	77	332	-1	953
Egypt	-185	14	22	18	1,668	359	1,467	1,686	5,049
Jordan	-9	-1	-3	-55	-203	-299	-489	-36	-1,094
Ethiopia	-1,319	-6	-2	-3	51	-25	-1,857	12	-3,149
Sudan	-1,311	-1	-1	-1	47	-58	-1,114	-101	-2,539
Israel	-261	-45	-19	-169	-1,628	-5,030	-13,111	-171	-20,435
Brazil	-231	799	301	129	1,277	2,445	13,521	1,728	19,969
United States	-735	167	487	71	11,726	1,447	45,318	1,397	59,878
Russia	29	85	32	16	1,569	1,198	5,357	540	8,827
EU	-5,391	-824	-166	-717	-5,659	-22,640	-35,849	-1,642	-72,888
East Asia	-5,851	914	3,716	5,678	48,873	-51,147	-16,223	-41,221	-55,259
Southeast Asia	-5,006	-974	834	-2,609	6,016	-3,772	-11,712	-10,733	-27,955
South Asia	-9,455	-55	274	-2,264	6,760	-6,692	-19,180	-2,799	-33,412
Central Asia	-1,263	6	14	22	237	902	-863	-165	-1,110
Oceania	-314	-23	26	-57	1,954	338	10,342	8,129	20,395
Indian Ocean	-41	0	0	5	6	6	-89	2	-112
Middle East	-1,058	287	46	7	968	-8,614	-3,775	7,519	-4,620
Mediterranean Sea	-15	-3	-1	-12	-112	-135	-686	0	-965
Eastern Europe	-418	-101	-65	-117	-730	-2,625	-4,874	-306	-9,236
Western Europe	-5,463	-760	-106	-607	-5,078	-22,187	-32,385	-1,560	-68,144
North Europe	-190	-19	4	11	-348	-2,229	-1,731	-371	-4,873
North Africa	-542	2	12	-17	1,818	196	-31	-297	1,140
Central Africa	-1,625	1	3	3	280	117	-2,476	-138	-3,833
Eastern Africa	-3,412	-8	-6	-40	212	-48	-3,956	-39	-7,298
Western Africa	-192	9	-1	18	368	58	-948	-489	-1,177
Southern Africa	-205	68	20	13	507	678	3,188	2,065	6,333
North America	-829	238	503	77	12,837	1,177	46,114	-711	59,405
Central America	-165	5	16	17	3,138	74	2,506	-93	5,498
South America	-749	971	340	257	8,466	5,511	20,273	2,418	37,487
World	-36,793	643	5,662	394	87,522	-87,399	-11,365	-38,284	-79,619

Source: Estimated by IDE-GSM.

Table 2: Economic impacts of the Suez Canal (% of GDP)

	Agriculture	Automotive	E&E	Textile	Food Proc.	Oth. Mfg.	Services	Mining	Real GDP
Indonesia	-1.8%	-0.3%	1.0%	-3.1%	2.2%	0.3%	-0.8%	-11.1%	-1.1%
Malaysia	-2.1%	-1.9%	0.4%	-7.7%	1.3%	-2.2%	-1.3%	-21.6%	-2.5%
Singapore	-3.5%	-2.9%	0.0%	-12.0%	-3.4%	-3.8%	-1.6%	-17.8%	-1.9%
Thailand	-1.7%	-1.7%	0.7%	-3.0%	2.5%	-0.5%	-0.1%	-1.2%	-0.3%
Philippines	-1.0%	0.5%	0.6%	-0.3%	6.3%	0.4%	0.4%	1.6%	0.8%
Vietnam	-1.6%	0.1%	0.7%	-2.1%	3.6%	-0.3%	0.2%	5.6%	0.3%
Japan	-0.4%	0.4%	0.3%	0.4%	6.9%	-0.9%	0.5%	-0.4%	0.5%
Korea	-0.8%	0.0%	0.1%	0.3%	6.7%	-2.8%	-1.0%	-16.7%	-1.1%
China	-1.2%	0.1%	0.4%	0.5%	6.9%	-1.0%	-0.5%	-9.0%	-0.5%
Australia	-0.7%	-0.3%	0.5%	-0.6%	5.6%	0.4%	0.7%	7.9%	1.2%
Taiwan	-0.6%	-0.3%	0.3%	1.0%	9.4%	-0.3%	0.4%	2.7%	0.4%
India	-1.7%	0.0%	0.3%	-1.7%	5.2%	-1.0%	-0.6%	-3.6%	-0.7%
Sri Lanka	-3.2%	-3.2%	0.0%	-8.2%	-2.1%	-2.1%	-2.8%	-4.1%	-3.4%
Swaziland	0.6%	1.0%	0.8%	0.7%	11.3%	0.9%	2.2%	0.2%	4.8%
Yemen	-0.5%	0.6%	0.2%	-0.4%	9.2%	0.5%	1.5%	4.4%	2.0%
Uruguay	-0.5%	1.0%	0.6%	0.5%	9.9%	1.2%	1.0%	-0.4%	1.9%
Egypt	-0.7%	1.0%	0.7%	0.8%	10.5%	1.4%	0.9%	5.2%	1.8%
Jordan	-3.2%	-1.4%	-0.9%	-5.0%	-9.2%	-4.7%	-2.2%	-18.5%	-3.4%
Ethiopia	-6.5%	-2.2%	-0.9%	-0.6%	9.6%	-0.8%	-3.9%	3.5%	-4.3%
Sudan	-6.5%	-0.9%	-0.8%	-0.5%	7.6%	-1.6%	-4.1%	-3.6%	-4.6%
Israel	-6.8%	-6.4%	-1.5%	-13.4%	-19.2%	-14.3%	-4.5%	-33.7%	-6.0%
Brazil	-0.8%	1.0%	0.7%	0.5%	7.8%	1.0%	0.7%	1.6%	0.8%
United States	-0.5%	0.1%	0.1%	0.2%	4.3%	0.1%	0.3%	0.4%	0.3%
Russia	0.1%	0.5%	0.4%	0.3%	2.4%	0.4%	0.4%	0.2%	0.4%
EU	-2.1%	-0.3%	-0.1%	-0.5%	-1.4%	-1.2%	-0.2%	-1.6%	-0.4%
East Asia	-1.0%	0.2%	0.3%	0.5%	6.9%	-1.0%	-0.1%	-8.5%	-0.2%
Southeast Asia	-1.7%	-1.1%	0.5%	-2.9%	3.4%	-0.8%	-0.6%	-9.5%	-0.9%
South Asia	-1.7%	-0.1%	0.3%	-1.8%	4.8%	-1.0%	-0.7%	-3.0%	-0.7%
Central Asia	-1.5%	0.4%	0.3%	0.6%	5.2%	1.1%	-0.3%	-0.2%	-0.2%
Oceania	-0.8%	-0.3%	0.5%	-0.8%	5.0%	0.3%	0.7%	7.5%	1.1%
Indian Ocean	-1.6%	-0.5%	0.2%	1.3%	4.9%	0.5%	-0.7%	5.9%	-0.6%
Middle East	-0.8%	0.4%	0.1%	0.0%	1.2%	-1.6%	-0.2%	1.2%	-0.1%
Mediterranean Sea	-1.8%	-3.2%	-1.0%	-8.3%	-11.1%	-5.0%	-1.6%	-0.4%	-2.0%
Eastern Europe	-0.6%	-0.3%	-0.2%	-0.3%	-1.0%	-0.9%	-0.2%	-0.9%	-0.3%
Western Europe	-2.6%	-0.3%	0.0%	-0.5%	-1.4%	-1.3%	-0.2%	-2.0%	-0.4%
North Europe	-0.8%	-0.1%	0.0%	0.2%	-0.5%	-0.7%	-0.1%	-0.6%	-0.3%
North Africa	-1.0%	0.1%	0.2%	-0.2%	8.3%	0.4%	0.0%	-0.2%	0.2%
Central Africa	-1.5%	0.1%	0.3%	0.3%	6.0%	0.3%	-0.8%	-0.4%	-0.7%
Eastern Africa	-4.8%	-1.2%	-0.6%	-2.7%	7.1%	-0.3%	-2.4%	-0.5%	-2.7%
Western Africa	-0.5%	0.7%	-0.1%	1.4%	5.5%	0.4%	-0.7%	-0.5%	-0.4%
Southern Africa	-0.9%	1.1%	0.6%	0.6%	8.5%	1.4%	0.8%	2.1%	1.0%
North America	-0.5%	0.1%	0.1%	0.1%	4.2%	0.1%	0.2%	-0.2%	0.3%
Central America	-0.5%	0.0%	0.1%	0.1%	2.2%	0.0%	0.2%	-0.1%	0.3%
South America	-0.9%	1.0%	0.6%	0.4%	7.0%	1.0%	0.7%	1.0%	0.9%
World	-1.4%	0.0%	0.3%	0.0%	3.7%	-0.7%	0.0%	-1.2%	-0.1%

Source: Estimated by IDE-GSM.

Table 3: Top 10 Regions damaged by the blockage of the Suez Canal (million USD)

Region	Country	Agriculture	Automotive	E&E	Textile	Food Proc.	Oth. Mfg.	Services	Mining	Real GDP
Tel Aviv*	Israel	-261	-45	-19	-169	-1,628	-5,030	-13,111	-171	-20,435
Shanghai	China	-57	7	134	462	915	-4,754	-3,310	-2,527	-9,130
Singapore*	Singapore	-93	-272	-6	-92	-93	-2,283	-3,561	-246	-6,645
Bern	Switzerland	-144	-10	-5	-20	-306	-1,984	-2,209	-21	-4,698
Guangzhou	China	-42	-22	364	-88	1,185	-743	-3,047	-1,830	-4,222
Seoul	Korea	-23	1	4	31	50	-85	-3,843	-249	-4,115
Suzhou	China	-27	5	73	437	307	-2,760	-924	-1,122	-4,010
Beijing	China	-37	19	32	187	883	-1,106	-2,178	-1,286	-3,487
Lombardia	Italy	-150	-15	-21	-52	-218	-1,272	-1,567	-28	-3,323
Central Jakarta	Indonesia	-36	-89	48	-167	106	61	-2,011	-1,097	-3,185

Source: Estimated by IDE-GSM.

Note: Region marked by * represents a country by one region.

Table 4: Top 10 Regions gained from the blockage of the Suez Canal (million USD)

Region	Country	Agriculture	Automotive	E&E	Textile	Food Proc.	Oth. Mfg.	Services	Mining	Real GDP
Rio de Janeiro*	Brazil	-231	799	301	129	1,277	2,445	13,521	1,728	19,969
California	United States	-127	8	124	9	1,185	229	6,226	88	7,741
Tokyo	Japan	-54	26	86	11	638	-606	7,082	-25	7,159
Santiago*	Chile	-12	7	4	12	1,975	1,512	1,669	222	5,389
New York	United States	-13	5	19	6	614	68	4,531	10	5,238
Western Australia	Australia	-23	-2	2	-3	149	38	1,301	3,772	5,235
Mexico City*	Mexico	-30	4	15	14	2,684	33	2,318	-84	4,955
New South Wales	Australia	-36	-7	7	-6	452	109	3,076	808	4,403
Texas	United States	-48	9	52	5	569	161	3,100	470	4,318
Bogota*	Colombia	-11	34	10	44	1,896	439	1,569	-41	3,941

Source: Estimated by IDE-GSM.

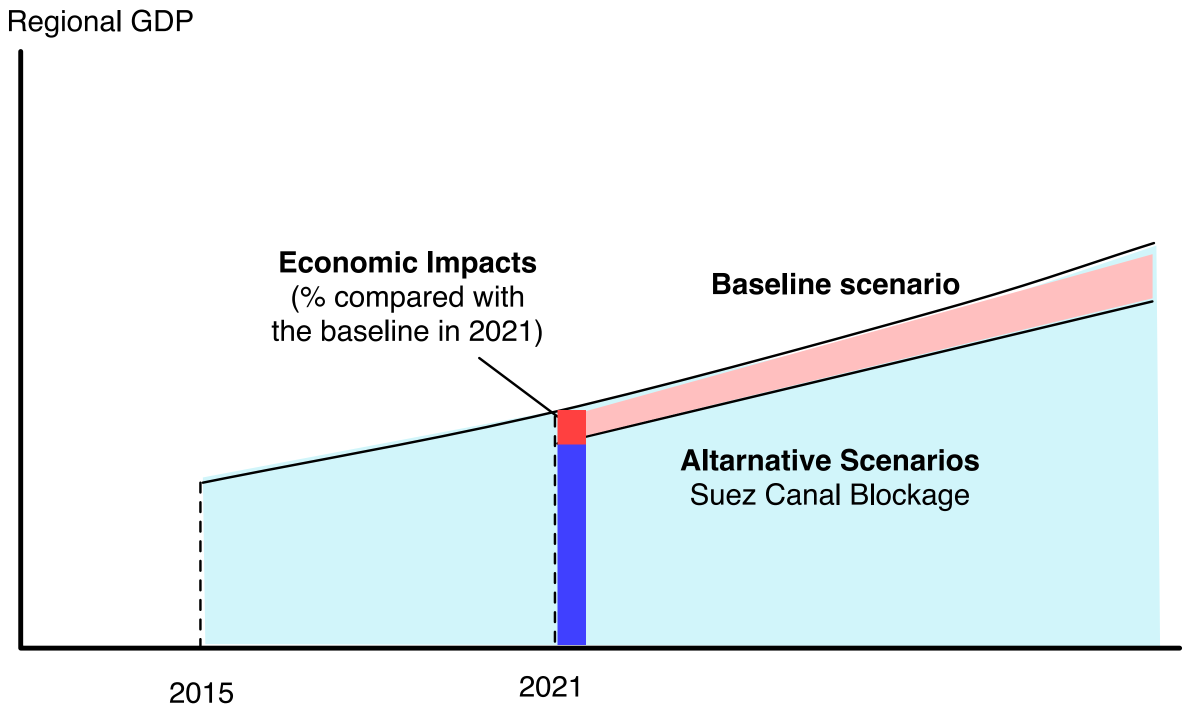
Note: Region marked by * represents a country by one region.

Table A1:Industry specific parameters

	Elasticity of substitution: σ	Share of labor input: β	Share in consumption: μ
Agriculture	3.8	0.41	0.035
Automotive	4	0.40	0.014
Electronics	6	0.40	0.022
Textile	8.4	0.37	0.015
Food	5.1	0.34	0.026
Others	5.3	0.44	0.129
Service	3	0.57	0.700
Mining	5.6	0.17	0.058

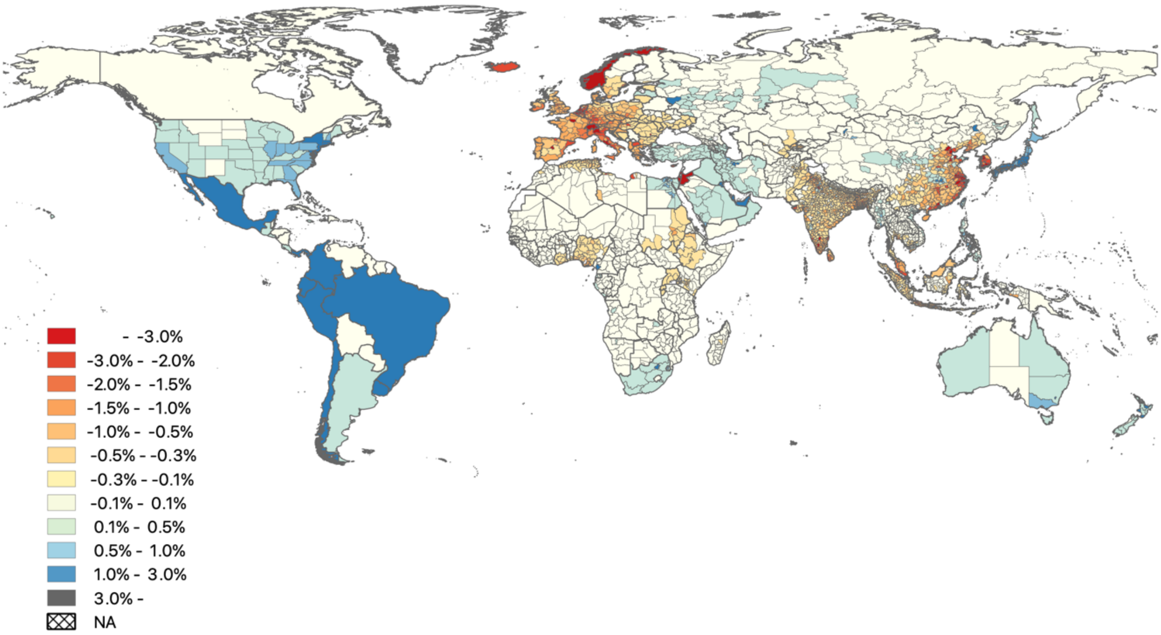
Source: Authors.

Figure 1: The method to calculate economic impacts



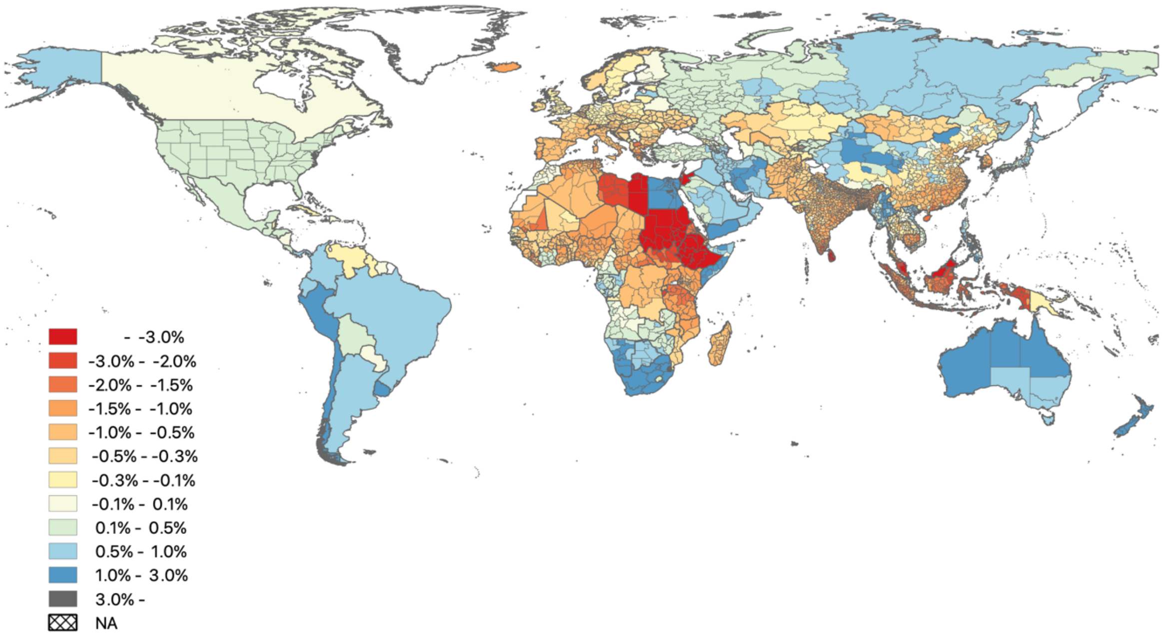
Source: Authors.

Figure 2: Economic Impacts of the Suez Canal (thousand USD/km2)



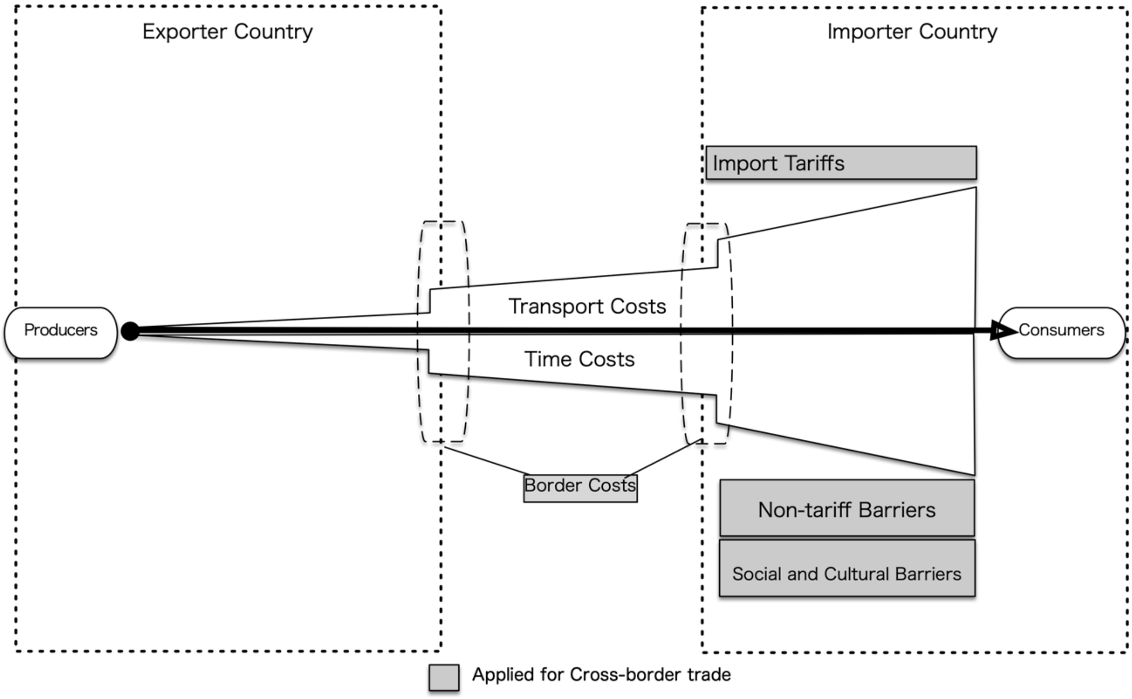
Source: Estimated by IDE-GSM.

Figure 3: Economic Impacts of the Suez Canal (% of Regional GDP)



Source: Estimated by IDE-GSM.

Figure A1: Trade costs taken into account in IDE-GSM



Source: Authors.