

# Geographical simulation analysis for logistics enhancement in Asia

著者	Kumagai Satoru, Hayakawa Kazunobu, Isono Ikumo, Keola Souknilanh, Tsubota Kenmei
権利	Copyrights 日本貿易振興機構 (ジェトロ) アジア経済研究所 / Institute of Developing Economies, Japan External Trade Organization (IDE-JETRO) <a href="http://www.ide.go.jp">http://www.ide.go.jp</a>
journal or publication title	IDE Discussion Paper
volume	369
year	2012-10-01
URL	<a href="http://hdl.handle.net/2344/1184">http://hdl.handle.net/2344/1184</a>

IDE Discussion Papers are preliminary materials circulated to stimulate discussions and critical comments

IDE DISCUSSION PAPER No. 369

**Geographical Simulation Analysis  
for Logistics Enhancement in Asia**

Satoru KUMAGAI,<sup>§a</sup> Kazunobu HAYAKAWA,<sup>b</sup> Ikumo  
ISONO,<sup>†c</sup> Souknilanh KEOLA<sup>a</sup> and Kenmei TSUBOTA<sup>a</sup>  
October 2012

**Abstract**

This paper presents a simulation of the reduction of several components in trade cost for Asia and examines its impact on the economy. Our simulation model based on the new economic geography embraces seven sectors, including manufacturing and non-manufacturing sectors, and 1,715 regions in 18 countries/economies in Asia, in addition to the two economies of the US and the European Union. The geographical course of transactions among regions is modeled as determined based on firms' modal choice. The model also includes estimates of some border cost measures such as tariff rates, non-tariff barriers, other border clearance costs, transshipment costs and so on. Our simulation analysis for Asia includes several scenarios involving the improvement/development of routes and the reduction of the above-mentioned border cost. We have shown that the contribution of physical and non-physical infrastructure improvements conducted together is larger than the sum of the contribution by each when conducted independently.

**Keywords:** Geographical simulation, new economic geography, Asia, trade cost

**JEL classification:** F15, O53, R15

---

<sup>a</sup> *Institute of Developing Economies, Japan External Trade Organization, Japan*

<sup>b</sup> *Bangkok Research Center, Japan External Trade Organization, Thailand*

<sup>c</sup> *Economic Research Institute for ASEAN and East Asia, Indonesia*

The Institute of Developing Economies (IDE) is a semigovernmental, nonpartisan, nonprofit research institute, founded in 1958. The Institute merged with the Japan External Trade Organization (JETRO) on July 1, 1998. The Institute conducts basic and comprehensive studies on economic and related affairs in all developing countries and regions, including Asia, the Middle East, Africa, Latin America, Oceania, and Eastern Europe.

---

The views expressed in this publication are those of the author(s). Publication does not imply endorsement by the Institute of Developing Economies of any of the views expressed within.

---

**INSTITUTE OF DEVELOPING ECONOMIES (IDE), JETRO**  
**3-2-2, WAKABA, MIHAMA-KU, CHIBA-SHI**  
**CHIBA 261-8545, JAPAN**

©20XX by Institute of Developing Economies, JETRO

No part of this publication may be reproduced without the prior permission of the IDE-JETRO.

# Geographical Simulation Analysis for Logistics Enhancement in Asia

Satoru KUMAGAI,<sup>§a</sup> Kazunobu HAYAKAWA,<sup>b</sup> Ikumo ISONO,<sup>†c</sup>  
Souknilanh KEOLA<sup>a</sup> and Kenmei TSUBOTA<sup>a</sup>

<sup>a</sup> *Institute of Developing Economies, Japan External Trade Organization, Japan*

<sup>b</sup> *Bangkok Research Center, Japan External Trade Organization, Thailand*

<sup>c</sup> *Economic Research Institute for ASEAN and East Asia, Indonesia*

**Abstract:** This paper presents a simulation of the reduction of several components in trade cost for Asia and examines its impact on the economy. Our simulation model based on the new economic geography embraces seven sectors, including manufacturing and non-manufacturing sectors, and 1,715 regions in 18 countries/economies in Asia, in addition to the two economies of the US and the European Union. The geographical course of transactions among regions is modeled as determined based on firms' modal choice. The model also includes estimates of some border cost measures such as tariff rates, non-tariff barriers, other border clearance costs, transshipment costs and so on. Our simulation analysis for Asia includes several scenarios involving the improvement/development of routes and the reduction of the above-mentioned border cost. We have shown that the contribution of physical and non-physical infrastructure improvements conducted together is larger than the sum of the contribution by each when conducted independently.

**Keywords:** Geographical simulation, new economic geography, Asia, trade cost

**JEL Classification:** F15, O53, R15

---

<sup>§</sup> We would like to thank Masahisa Fujita and Toshitaka Gokan for their numerous comments.

<sup>†</sup> Corresponding author: Ikumo Isono, Address: Economic Research Institute for ASEAN and East Asia, Sentral Senayan II 6th Floor, Jl. Asia Afrika No.8. Gelora Bung Karno Senayan, Jakarta Pusat 10270, Indonesia. Tel: +62-21-5797-4460, Fax: +62-21-5797-4463, Email: [ikumo.isono@eria.org](mailto:ikumo.isono@eria.org).

## **1. Introduction**

It is becoming increasingly important to construct economic models better suited to analysis of Asia, which formed sophisticated international production networks during a period of dramatic activity during the so-called “Asian Miracle” in the early 1990s and during the severe currency crisis in 1997/1998. Asian factories churned out millions of different consumer products with world-beating price-quality ratios by sourcing billions of different parts and components from plants spread across a dozen nations in Asia. In short, as stated in Baldwin (2006), East Asian corporations set up “Factory Asia”. In order to grasp the complicated nature of Factory Asia and examine changes in its behavior, we need economic models that can accurately describe the economic mechanics and capture the important economic factors in Asia.

In constructing economic models for Asia, at least two viewpoints should be taken into consideration. The first one concerns the mechanics of new economic geography (NEG). NEG allows us to explore the impact of the reduction in trade costs on industrial distribution, which is developed by Fujita, Krugman and Venables (1999). Several studies have applied the mechanics of NEG in the computable general equilibrium (CGE) model in order to investigate such impact, mostly for Europe, where the trade cost has already been low for some time. For example, employing such a CGE model for Europe, Forslid et al. (2002b), Forslid et al. (2002a) and Bosker, Brakman, Garretsen and Schramm (2010) examine the impact of trade cost reduction on industrial distribution. Compared to European and North American countries, Asian countries are characterized by relatively high trade costs. In Asia, even basic infrastructure such as well-paved roads tend to be less developed in many countries, and various kinds of border costs such as tariff and non-tariff barriers have remained at a high level. As a result, a reduction of trade costs would be expected to yield a more drastic change in industrial distribution in Asia than in Europe. Such a phenomenon can be captured well by the NEG model.

The second viewpoint concerns the use of detailed geographical units. As mentioned above, in Asia, basic infrastructure such as well-paved roads has remained less developed in many Asian countries, and even within one country there may exist huge gaps in the quality of infrastructure. Therefore, it becomes crucial to take into account the extent of connectivity not only across countries but also across, say, provinces within each country. This implies that it is necessary to conduct analysis at the sub-national level in order to examine the economic impact of changes in the important components of trade costs in the case of Asia. However, it is much more difficult to collect sub-national level data in less developed countries. Such data is not

available in a ready-made format, unlike in European countries which have EUROSTAT. Indeed, although there are several papers analyzing the economic impact of trade cost reduction in the context of Asia (e.g., Francois and Wignaraja 2008, Siriwardana 2003, Urata and Kiyota 2005, Plummer and Wignaraja 2006), no studies have investigated such impact at the sub-national level. Without the NEG model at the sub-national level, in the case of Asia, it would be difficult to obtain more accurate simulation results of trade cost reduction.

The purpose of this paper is to illustrate the impact of trade cost reduction on the Asian economy by employing a sub-national level model based on NEG. Our model comprises seven sectors, including manufacturing and non-manufacturing sectors, and 1,715 regions in 18 countries/economies in Asia in addition to the two economies of the US and the European Union. The Asian countries/economies are Bangladesh, Brunei Darussalam, Cambodia, China, Hong Kong, India, Indonesia, Japan, Korea, Lao PDR, Macao, Myanmar, Malaysia, Philippines, Singapore, Taiwan, Thailand and Vietnam. In addition, the currently available routes consisting of highways, railways, sea shipment and air shipment are incorporated in our model. The geographical route of transactions among regions is determined by firms' modal choice which reflects the type of goods. The model also includes estimates of some border cost measures such as tariff rates, non-tariff barriers, other border clearance costs, transshipment costs and so on. Thus, our simulation model is a comprehensive one for examining the impact of broadly-defined trade costs. By applying the sub-national level data, which is drawn from various kinds of data sources including unpublished ones, to this model, we examine several scenarios involving the improvement/development of transport routes and the reduction of the above-mentioned border cost.

The remainder of this paper is organized as follows. In Section 2, the simulation model is presented. In Section 3, we provide our data sources and parameter values used in the simulation model. Section 4 explains our simulation procedures, and then the results of our simulation for the reduction of transport costs are presented in Section 5. Finally, we conclude this paper in Section 6.

## **2. Model**

In this section, we explain the NEG model that we use in our simulation. The schematic description of the model is found in Figure 1. Our model is multi-region and multi-sector and consists of the agriculture sector, five manufacturing sectors and the service sector. Our model allows mobility of workers within each country and between

sectors. While the transport cost of agricultural goods is assumed to be costless, that of manufactured goods and services is assumed to be the iceberg type. Our theoretical foundation follows Puga and Venables (1996), which captures the multi-sector and country general equilibrium of NEG. Therefore, the explanation below is almost limited to equations in equilibrium. However, it is worth noting that our model differs from that of Puga and Venables (1996) in terms of the specification in the agriculture sector. We have explicitly incorporated land size in agricultural production and have kept agricultural technology as constant returns to scale.<sup>1</sup>

==== Figure 1 ====

Nominal wage rates in the agriculture sector are derived from cost minimization in the agriculture sector subject to the production function of the agriculture sector:

$$f_A(i) = A_A(i)L_A(i)^\alpha F(i)^{1-\alpha}, \quad (1)$$

where  $f_A(i)$  is the amount of agricultural product produced at location  $i$ ;  $A_A(i)$  is the efficiency of production at location  $i$ ,  $L_A(i)$  represents the labor inputs of the agriculture sector at location  $i$ , and  $F(i)$  is the area of arable land at location  $i$ . Since the price of an agricultural good is the same in all locations, nominal wage rates in the agriculture sector in location  $i$ , which is expressed as  $w_A(i)$ , are the value of the marginal product for labor input as follows:

$$w_A(i) = A_A(i)\alpha \left( \frac{F(i)}{L_A(i)} \right)^{1-\alpha}. \quad (2)$$

Note that agricultural price is chosen as the numeraire so that it is identical across regions.

In order to capture the concentration of particular sectors, we assume the firms in the manufacturing sector are monopolistically competitive, and their inputs are assumed to be labor and intermediate goods as in Eaton (1982). Manufacturing firms at location  $i$  produce their products using the composite of the labor and manufacturing aggregate, and their production functions are expressed as a linear function of production quantity with a fixed input requirement,  $f_M + (m(v)/A_M(i))$ , where  $m(v)$  is the quantity produced by a manufacturing firm indexed  $v$ .<sup>2</sup> We assume that the technology is identical for all

<sup>1</sup> For detailed derivations, see Puga and Venables (1996) and Fujita et al. (1999).

<sup>2</sup> In the actual model, the manufacturing sector is divided into five sub-sectors. So, the subscript  $M$  consists of  $M_1$  to  $M_5$ . For simplicity, these subsectors are represented as a group by the ‘‘Manufacturing’’ sector in this description.

varieties and in all locations. The price of manufactured goods is set as:

$$p_M(i) = w_M(i)^\beta G_M(i)^{1-\beta} / A_M(i),$$

where  $W_M(i)$  is the nominal wage of the manufacturing sector at location  $i$ ,  $A_M(i)$  is location and industry specific efficiency of labor, and  $G_M(i)$  is the price index of manufactured goods at location  $i$ .<sup>3</sup> We assume that the marginal input requirement is supposed to equal to the price-cost markup. Consequently, the location of firms depends on two factors, i.e., the supply of the other manufacturing firms and the demand for manufactured goods. This relation exhibits the concentration of manufacturing firms in particular regions. The price index of manufactured goods at location  $i$  is expressed as follows:

$$G_M(i) = \left[ \sum_{j=1}^R L_M(j) A_M(i)^{\sigma_M-1} w_M(j)^{-(\sigma_M-1)\beta} G_M(j)^{-\sigma_M(1-\beta)} T_{ji}^{M(\sigma_M-1)} \right]^{-\frac{1}{(\sigma_M-1)}}, \quad (3)$$

where  $T_{ij}^M$  stands for the iceberg transportation costs from location  $i$  to location  $j$  for manufactured goods and  $\sigma_M$  is the elasticity of substitution between any two differentiated manufactured goods.

In contrast to the manufacturing sector, the service sector may not require intermediate goods for production. We assume that the technology of the service sector only requires labor input and exhibits increasing returns to scale.<sup>4</sup> Its cost function can be expressed by  $w_S(i) f_S + w_S(i) (q_S(v)/A_S(i))$ , where  $q_S(v)$  is the quantity of services produced by a firm. The price of services is set as  $p_S(i) = w_S(i)/A_S(i)$ , where  $w_S(i)$  is the nominal wage of the service sector at location  $i$  and  $A_S(i)$  is the production efficiency of the service sector at location  $i$ . The price index of services at location  $i$  is expressed as follows:

$$G_S(i) = \left[ \sum_{j=1}^R L_S(j) A_S(i)^{\sigma_S-1} w_S(j)^{-(\sigma_S-1)} T_{ji}^{S(\sigma_S-1)} \right]^{-\frac{1}{(\sigma_S-1)}} \quad (4)$$

where  $T_{ij}^S$  is the iceberg transportation costs from location  $i$  to location  $j$  for services and  $\sigma_S$  is the elasticity of substitution between any two differentiated services. We choose

<sup>3</sup> As in Puga and Venables (1996), inter-industrial linkage can be captured in our analysis. However, for simplicity we drop the inter-industrial linkage across manufacturing and keep the linkage within the same manufacturing sector.

<sup>4</sup> Kolko (2010) shows “services industries that trade with each other are more likely to collocate in the same zip code, though not in the same county or the same state; in contrast, manufacturing industries that trade with each other are more likely to collocate in the same county or state but not at the zip code level”. We describe this feature of services by not assuming the intermediate inputs from the own industry in services and avoiding intermediate inputs from the other regions.



the production units as the inverse of the consumption share of services. The number of varieties of services is decided from the equality of wage payment and the expenditure share of labor at location  $i$ .

Regional incomes in the NEG model correspond to regional GDPs (in terms of numeraire) in our simulations. Supposing that revenues from land at location  $i$  belong to households at location  $i$ , then GDP at location  $i$  is expressed as follows:

$$Y(i) = f_A(i) + w_M(i)L_M(i) + w_S(i)L_S(i) \quad (5)$$

where  $w_M(i)$  and  $w_S(i)$  are, respectively, nominal wage rates in the manufacturing sector and the services sector at location  $i$ , and  $L_M(i)$  and  $L_S(i)$  are labor input of the manufacturing sector and the services sector at location  $i$ , respectively.<sup>5</sup>

Regional expenditure on manufactured goods at location  $i$ , which is expressed as  $E(i)$ , consists of household purchases as final consumption and manufacturing firms as intermediary consumption:

$$E(i) = \mu_M Y(i) + \frac{1-\beta}{\beta} w_M(i)L_M(i) \quad (6)$$

where  $\mu_M$  is the consumption share of expenditures on manufactured goods and  $\beta$  is the input share of labor in output. In equation (6), the first term shows the expenditure on manufactured goods, and the second term expresses the expenditure on manufactured goods as an intermediary purchase since  $1-\beta$  shows the expenditure share for intermediary purchases of manufacturing firms.

Nominal wages in the manufacturing sectors at location  $i$  at which firms in each location break even are expressed as follow:

$$w_M(i) = \left[ \frac{A_M(i) \beta^{\frac{1}{\sigma_M}} \left[ \sum_{j=1}^R E(j) T_{ij}^{M1-\sigma_M} G_M(j)^{-(1-\sigma_M)} \right]^{\frac{1}{\sigma_M}}}{G_M(i)^{1-\beta}} \right]^{\frac{1}{\beta}}. \quad (7)$$

Similarly, nominal wages in the service sector at location  $i$  are expressed as follow:

$$w_S(i) = A_S(i) \left[ \sum_{j=1}^R Y(j) T_{ij}^{S1-\sigma_S} G_S(j)^{-(1-\sigma_S)} \right]^{\frac{1}{\sigma_S}}. \quad (8)$$

From (1) to (8), the variables are decided using a given configuration of labor.

---

<sup>5</sup> With the normalization of the agricultural product,  $f_A(i)$  expresses the value of the agricultural product produced at location  $i$  which is equal to the wage bill for farmers and land rents.

Derived regional GDP, nominal wage rates, and price indexes are used to determine labor's decision on a working sector and place. Within a location, since mobility across sectors is allowed, the dynamics of sectoral migration are expressed as follows:

$$\dot{\lambda}_I(i) = \gamma_I \left( \frac{\omega_I(i)}{\bar{\omega}(i)} - 1 \right) \lambda_I(i), \quad I \in \{A, M, S\}, \quad (9)$$

where  $\dot{\lambda}_I(i)$  is the change in labor (population) share for a sector within a location,  $\gamma_I$  is the parameter used to determine the speed of switching jobs within a location,  $\omega_I(i)$  is the real wage rate of any sector at location  $i$ , and  $\bar{\omega}(i)$  is the average real wage rate at location  $i$ .

Among regions, the dynamics of labor migration are expressed as follows:

$$\dot{\lambda}_L(i) = \gamma_L \left( \frac{\omega(i)}{\bar{\omega}_c} - 1 \right) \lambda_L(i), \quad (10)$$

where  $\dot{\lambda}_L(i)$  is the change in the labor (population) share of a location in a country,  $\gamma_L$  is the parameter for determining the speed of migration between locations, and  $\lambda_L(i)$  is the population share of a location in a country. In (10),  $\omega(i)$  shows the real wage rate of a location and is specified as follows:

$$\omega(i) = \frac{Y(i)/(L_A(i) + L_M(i) + L_S(i))}{G_M(i)^\mu G_S(i)^\rho}, \quad (11)$$

where  $\rho$  shows the consumption share of services. Furthermore,  $\bar{\omega}_c$  in (10) shows the average real wage rate in country  $c$ . Expressions in (10) and (11) show that each region has a different per capita regional GDP and price index and also that labor migration is determined by a comparison of these factors across regions.

### 3. Data and Parameters

This section provides the sources of data for our simulation analysis. Then, we present the values of several parameters in the simulation model.

#### 3.1. Data

The data used in our simulation covers 18 countries/economies, including 1,715 regions in total. Based mainly on official statistics, we derive the regional GDP (GRDP) of the agriculture sector, five manufacturing sectors and the service sector for year 2005.

The five manufacturing sectors are agricultural and food processing, garment and textiles, electronics, automotive and other manufacturing. The population and the area of arable land in each region are also compiled from various statistics. The administrative unit adopted in the simulation is one level lower than the national level for Cambodia, Japan, Korea, Lao PDR, Myanmar, Malaysia, Philippines, Taiwan, Thailand, and Vietnam. For Bangladesh, China, India and Indonesia, the administrative unit is two levels lower than the national level. Brunei Darussalam, Hong Kong, Macao and Singapore are treated as one unit respectively. The US and European Union are included as one unit respectively.

Specifically, our data sources are composed of several kinds of censuses and surveys conducted in each country. Some unique data sources are as follow. For Cambodia, we use the estimates of provincial income and employed labor in three industries, namely, primary, secondary, and tertiary industries, based on Cambodia's socioeconomic survey conducted between 2003 and 2005. Those estimates are provided by the Japan International Cooperation Agency. The provincial-level figures for Lao PDR were obtained from unpublished annual provincial reports concerning the implementation of their socioeconomic plan. For India, the manufacturing GRDP for five sectors was compiled from the value added by industry with the Indian annual survey of industry. The provincial data for Myanmar was obtained from the Household Income and Expenditure Survey, published by the Central Statistical Organization. Even with these data sources, for some countries, we cannot obtain the GRDP of the five manufacturing sectors separately. In this case, the sectoral-level GRDP is derived by multiplying the GRDP of the total manufacturing industry at the provincial level by the share of each sector's GDP at the national level. A summary of the resulting regional statistics is provided in Table 1.

==== Table 1 ====

### **3.2. Transport Costs**

Our transport cost consists of physical transport costs, time costs, tariff rates and non-tariff barriers. The physical transport costs are a function of travel distance, travel speed per hour, physical travel cost per kilometer, and holding cost for domestic/international transshipment at border crossings, stations, ports or airports. The time costs depend on travel distance, travel speed per hour, time cost per hour, holding time for domestic/international transshipment at border crossings, stations, ports or airports. These parameters for physical transport and time costs are listed in Table 2.

Also, time cost per hour perceived by firms is set at 15.7 for food, 17.2 for textiles, 144.2 for machineries, 16.9 for automobiles and 16.5 for others. The travel speed per hour is provided in the next section. These parameters are derived from the ASEAN Logistics Network Map 2008 by JETRO and by estimating the model of the firm-level transport mode choice using the “Establishment Survey on Innovation and Production Network” (ERIA) for 2008 and 2009, which includes manufacturing firms in Indonesia, Philippines, Thailand and Vietnam. Based on these parameters, we calculate the sum of physical transport and time costs for all possible routes between two regions. Then, employing the Floyd-Warshall algorithm for the determination of the optimal route and transport mode for each region and good, we obtain the sum of physical transport and time costs for each pair of regions by industry (Cormen et al. 2001).<sup>6</sup>

==== Table 2 ====

The sum of tariff and non-tariff barriers (TNTB) is estimated by employing the “log odds ratio approach”, which was initiated by Head and Mayer (2000). Namely, we estimate the industry-level border barriers for each country. Our data source for the dependent variable (i.e., the ratio of imports from a country to domestic consumption) is the Asian International Input-Output Table for 2000 published by the Institute of Developing Economies (IDE). The explanatory variables include the above-calculated sum of physical transport and time costs and the ratio of GDP per capita in a country to the domestic GDP per capita. With this methodology, we estimate industry-level TNTB for Indonesia, Malaysia, Philippines and Thailand. The TNTB for the rest of our sample countries are obtained by prorating those four countries’ TNTB according to the number of days for customs clearance in each country, for which data is drawn from the “Doing Business Indicator” of the World Bank. Then, by subtracting tariff rates from TNTB, we obtain the non-tariff barriers (NTBs). Our data source for tariff rates is the World Integrated Trade Solution (WITS), particularly TRAINS raw data. As a result, we obtain separately (bilateral) tariff rates and (importer-specific) NTBs by industry, on a tariff equivalent basis. Lastly, our total transport costs were the product of the sum of physical transport and time costs and the sum of tariff rates and NTBs.

---

<sup>6</sup> The road network has been constructed not by direct distance between cities but by approximated road links on maps. This is clearly different from equidistance analyses such as Stelder (2005). In this sense, our method is similar to that in Bosker et al. (2010), which conduct a simulation analysis for EU with a realistic non-equidistance. Also, note that Bosker et al. (2010) show the theoretical implication obtainable from the equidistant two-region model can be demonstrated by the non-equidistant multi-region model, which is the same as the framework of our analysis.

### 3.3. Some Other Parameters

We adopt the elasticity of substitution for manufacturing sectors from Hummels (1999) and estimate that for services as follow: 5.1 for food, 8.4 for textiles, 8.8 for electronics, 7.1 for transport, 5.3 for others and 5.0 for services. The estimates for the elasticity of services are obtained from the estimation of the usual gravity equation for services trade, including importer's GDP, exporter's GDP, importer's corporate tax, geographical distance between countries, a dummy for free trade agreement, a linguistic commonality dummy and the colonial dummy as independent variables. The elasticity of services is obtained from the transformation of a coefficient for the corporate tax because it directly changes services' prices. For this estimation, we mainly employ data from "Organisation for Economic Co-operation and Development (OECD) Statistics on International Trade in Services".<sup>7</sup>

Parameters  $\beta$ ,  $\mu$  and  $\rho$  are obtained as follow. The consumption share of consumers by industry (i.e.,  $\mu$ ) is uniformly determined for the entire region in the model. It would be more realistic to change the share by country or region; however, we cannot do this due to the lack of reliable consumption data. Therefore, the consumption share by industry is set to be identical to the GDP share by industry for the entire region as follows: 0.0800 for agriculture, 0.0322 for food, 0.0243 for textiles, 0.0201 for electronics, 0.0232 for automotive, 0.1729 for others and 0.6470 for services (i.e.,  $\rho$ ). The single labor input share for each industry (i.e.,  $1-\beta$ ) is uniformly applied to the entire region and the entire time period in the model. Although it may differ both among countries/regions and across years, we use an "average" value, in this case that of Thailand as a country in the middle stage of economic development, which is again taken from the Asian International Input Output Table 2000 by IDE. As a result, the parameter of  $\beta$  is 0.367 for agriculture, 0.204 for food, 0.346 for textiles, 0.367 for electronics, 0.379 for automotive, 0.267 for others and 0 for services.

## 4. Simulation Procedures

This section explains our simulation procedures, which are depicted in Figure 2.

---

<sup>7</sup> The use of OECD data presents two kinds of shortcomings. The first is that trade statistics for services in the OECD database are based on balance of payments, which primarily covers modes 1 and 2. This means that our estimate is based on an extremely limited area of services. Secondly, data on trade between non-OECD countries is not widely available. Thus, the OECD database excludes almost all trade among our GSM sample countries. In other words, our estimation is valid only when we assume that the elasticity of substitution in services is almost the same between developed countries (OECD countries) and developing countries (GSM countries).

Firstly, with the given distribution of employment and regional GDP by sector and by regions, short-run equilibrium is obtained. Observing the achieved equilibrium, workers migrate among regions as in equation (10), and we obtain a new distribution of workers and economic activities. With this new distribution and predicted population growth, the next short-run equilibrium is obtained for the following year, and we observe migration again. These computations are iterated for 25 years, i.e., up to 2030. Importantly, in the case of our simulation analysis, the economic impact of changes in trade and transport facilitation measures (TTFMs) is obtained as the difference in GDP or GRDP between the baseline scenario and an alternative scenario, typically 15 years after the implementation of specific TTFMs. TTFMs include the development of physical infrastructure (PI), customs facilitation measures (CF), reduction in non-tariff barriers (NTBs) and reduction in tariffs.

==== Figure 2 ====

In the simulation, we impose the following assumptions for all scenarios (including baseline and alternative scenarios). Firstly, there is no immigration between the region covered in the simulation and the rest of the world. Indeed, such immigration, particularly by unskilled laborers, is politically prohibited in East Asia. Secondly, the national population of each country is assumed to increase at the medium variant rate forecast by the United Nations Population Division until year 2030. This assumption is aimed at incorporating economic growth through the increase of population into our simulation model. Thirdly, the parameters of labor efficiency (i.e.,  $A$ ) for all countries and all industries are assumed to increase at 1% per year in order to incorporate the natural growth through the remaining elements into the model.<sup>8</sup>

In the baseline scenario, TTFM settings remain unchanged throughout the simulation period of 2005 through 2030, except for the updates of TTFMs in 2010 and 2015. For instance, the average speed of land traffic is set at 38.5 km/h. However, the speed on roads passing through mountainous areas is set to half of that (i.e., 19.25 km/h) and certain roads are set at 60 km/h (i.e., the roads in Thailand except for the Bangkok metropolitan area (due to traffic jams) and the road from the border of Thailand to Singapore through the west coast of Malaysia). As for sea traffic, the average speed is set at 14.7 km/h between international-class ports and at half of that on other routes.<sup>9</sup> For air

---

<sup>8</sup> We conduct some robustness checks for our simulation results by changing some of the parameter values, but the results are qualitatively unchanged. Those results are available upon request.

<sup>9</sup> The figures 38.5 and 14.7 are based on our estimation of the firm-level transport mode choice using the Establishment Survey on Innovation and Production Network for 2008 and 2009.

traffic, the average speed is set at 800 km/h between the primary airports of each country and at 400 km/h on other routes. As for railway traffic, the average speed is set at 19.1 km/h. The updates of TTFMs in 2010 and 2015 are as follow. In 2010, the following roads were upgraded to 60km/h, i.e., the Golden Quadrilateral National Highway of India and the route between Sisophon and Poipet in Cambodia. In 2015, the North-South and East-West Corridors in India and the route between Yangon and Mandalay in Myanmar are scheduled for completion. In addition, we prohibit transit trade through Myanmar and through Bangladesh, in keeping with the current situation. Therefore, trade between China and India is mainly carried out by ocean routes passing through the Malacca Straits or by air routes.

In this paper, as an example, we run a simulation of the development of the Mekong-India Economic Corridor (MIEC). The MIEC is planned to connect Vietnam, Cambodia, Thailand, Myanmar and India. This development plan is composed of two parts. The first part is a combination of construction and upgrading of the highway from Vietnam to Myanmar.<sup>10</sup> The second part is the development of the new port at Dawei in Myanmar with the establishment of some new sea routes to India and Europe.<sup>11</sup> For the highway part, 1) the bridge over the Mekong River at Neak Loueng has been constructed and 2) Dawei and Kanchanaburi in Thailand are connected by road. For the sea route, we connect Dawei in Myanmar with three ports (Port of Chennai, Port of Kolkata and Port of Rotterdam) by sea routes that are equivalent to the other routes between internationally important ports. In short, only under this scenario do we allow transit trade through Myanmar.

Under the development of the MIEC, our simulation includes the following three scenarios, namely, 1) the development of the above-mentioned physical infrastructure with customs facilitations (PI and CF), 2) the reduction in NTBs without any development of physical infrastructures (NTBs), and 3) a combination of 1) and 2). In the simulation model, PI is reflected in the improvement of the average speed of specific routes between regions or in the establishment of new routes between two regions/ports/airports/railway stations. CF is reflected in the reduction of time and money costs at ports, airports, land borders or stations typically by half. The reduction of NTBs is implemented as a 10% reduction in 15 years starting from 2015.<sup>12</sup>

---

<sup>10</sup> With the support of the Asian Development Bank, discussion on international cooperative development started in 1992 among the countries in the Greater Mekong Subregions, including Cambodia, China, Lao PDR, Myanmar, Thailand and Vietnam.

<sup>11</sup> There is continuous interest from the neighboring countries in the possibility of an international port at Dawei, Myanmar. See, for example, "The Energy Ties that Bind India, China" in *Asia Times* on 12<sup>th</sup> April 2005.

<sup>12</sup> Reduction in NTBs would include streamlining the official procedures before shipping,

## 5. Simulation Results

In this section, we report our simulation results. Firstly, we show the economic impact of physical infrastructure development (PI) and customs facilitation (CF) along MIEC, compared with the baseline scenario in 2030. Introduction of CF has reduced by half the overhead time at three borders (Kanchanaburi–Dawei, Ban Khlong Luek–Poipet and Bavet–Moc Bai), while the monetary costs incurred by crossing these borders have also been reduced to half of that in the baseline scenario.

The simulation results, shown in Figure 3 (focusing on the Mekong region), indicate that the development of these infrastructures does not always make all the regions better off. The Tanintharyi Region of Myanmar, which contains Dawei Port and shares a border with Thailand, benefits from PI and CF most, while other parts of Myanmar experience negative economic impact from PI and CF. This contrasting result indicates that PI and CF have strong redistributive effects on economic activities in Myanmar. For Thailand, the positive impact of PI and CF is small but spread all over the whole country, while the economic impact of PI and CF is strong in the region along MIEC for Cambodia and Vietnam. It is interesting to see that Lao PDR, which MIEC does not go through, also gains positive economic impact from PI and CF. This result in Lao PDR can be interpreted to mean that the development of Dawei Port improves market access to India and Europe from Lao PDR. In sum, for some regions, there are direct benefits in terms of improvement in market access, while other regions distant from the development experience an outflow of industries.

=== Figure 3 ===

We have also simulated the scenarios of PI only and CF only, though we do not present them in this paper due to space considerations.<sup>13</sup> The interesting results are as follow. Firstly, PI affects the regions along the corridor most. Secondly, CF has larger positive effects on the regions near the national borders, e.g., Banteay Meanchey of Cambodia and Tanintharyi of Myanmar. Thirdly, the scenario with PI and CF together exhibits more than the sum of PI only and CF only in most of the regions, except the border regions. This can be interpreted as meaning that the direct impact of CF is

---

eliminating trade quotas, and improving transparency in sanitary, phytosanitary, intellectual property rights measures and so on.

<sup>13</sup> The results are available upon request.



limited without PI. With PI, the impact can be spread out along the economic corridor. Lastly, negative effects from CF are observed only in Phnom Penh, which is the capital of Cambodia. This can be interpreted as being due to the distribution change observed in Mexico and described by Krugman and Elisond (1996). Since CF produces a reduction in trans-border costs, the relative advantage of frontier regions increases, and the capital city originally having a concentration of economic activities loses its relative advantage.

Next, we examine the impact of a 10% reduction of NTBs in 15 years starting from 2015 for MIEC-related countries, namely, Cambodia, India, Myanmar, Thailand and Vietnam. The economic impact is shown in Figure 4 (focusing on the Mekong region). Generally, the economic impact of the reduction of NTBs is spread over the regions within a country. Myanmar and Cambodia are two examples. Since NTBs act as an implicit cross-border cost, a reduction in NTBs appears as a nationwide improvement in access to foreign markets in each country. On top of this, the regions that have major international ports and/or airports seem to gain more. The regions around Bangkok, Ho Chi Minh City and Hanoi are three examples. This result is understandable because these regions have many more international transactions in goods and services. On the other hand, Lao PDR, which does not reduce its own NTBs, receives very little economic impact from its neighboring countries' reduction in NTBs.

=== Figure 4 ===

Lastly, we combined the above two scenarios, i.e., PI and CF, with the MIEC countries' reduction in NTBs. Figure 5 shows the combined economic impacts of PI, CF, and NTBs, compared with the baseline scenario in 2030. All the regions have positive economic impacts. The economic impact on the northwestern part of Myanmar also turned to positive. The positive economic impacts of Thailand, Cambodia, and Vietnam are all more pronounced. Even Lao PDR, which does not reduce its own NTBs, benefits slightly more than in the separate cases of PI and CF. Also, taking a closer look at these three kinds of simulation results in regions along the MIEC, we can see that the impact of combined implementation of PI and CF with the reduction in NTBs is larger than the sum of those of separate implementations (Table 3). On average, such "synergy effect" is 0.18%.

=== Figure 5 & Table 3 ===

## **6. Conclusion**

Our analysis adds realistic geography to the NEG model and generates policy implications for further regional integration in Asia. As a result, our simulation model reveals the future economic geography of Asia. While physical infrastructure improvements are expected to have a drastic impact on the distribution of economic activities, we found that the positive effects of physical transport infrastructure improvements are rather limited to the neighboring regions of the projects and that the existing concentrations of economic activities are rather persistent. Furthermore, we also find that, besides the ongoing physical transport infrastructure improvements, further trade facilitation or tackling behind-the-border issues among countries could enhance the prevalence of economic growth in each country.

## References

- Baldwin, R., 2006. Managing the noodle bowl: The fragility of East Asian regionalism. CEPR Discussion Papers, No. 5561.
- Bosker, M., Brakman, S., Garretsen, H., Schramm, M., 2010. Adding geography to the new economic geography: bridging the gap between theory and empirics. *Journal of Economic Geography*, 10(6), 793-823.
- Cormen, T.H., Leiserson, C.E., Rivest, R.L., Clifford, S., 2001. *Introduction to Algorithms*, MIT Press.
- Either, W., 1982. National and international returns to scale in the modern theory of international trade. *American Economic Review*, 72, 389-405.
- Forslid, R., Haaland, J.I., Midelfart-Knarvik, K.H., 2002a. A U-shaped Europe?: A simulation study of industrial location. *Journal of International Economics*, 57(2), 273-297.
- Forslid, R., Haaland, J.I., Midelfart-Knarvik, K.H., Maestad, O., 2002b. Integration and transition: Scenarios for the location of production and trade in Europe, *The Economics of Transition*, 10(1), 93-117.
- Francois, J.F., Wignaraja, G., 2008. Economic implications of Asian integration. *Global Economy Journal*, 8(3), 1-46.
- Fujita, M., Krugman, P., Venables, A.J., 1999. *The Spatial Economy: Cities, Regions, and International Trade*, Cambridge, MA: MIT Press.
- Hummels, D., 1999. Toward a geography of trade costs. GTAP Working Paper No. 17.
- Kolko, J., 2010. Urbanization, agglomeration, and coagglomeration of service industries. in: Glaeser, E.L. (Eds.), *Agglomeration Economics*, University of Chicago Press, pp. 151-180
- Krugman, P., Elizondo, R.L., 1996. Trade policy and the third world metropolis. *Journal of Development Economics*, 49(1), 137-150.
- Plummer, M.G., Wignaraja, G., 2006. The post-crisis sequencing of economic integration in Asia: Trade as a complement to a monetary Future. *Economie Internationale*, 3Q, 59-85.
- Puga, D., Venables, A.J., 1996. The spread of industry: Spatial agglomeration in economic development. *Journal of the Japanese and International Economies*, 10 (4), 440-464.
- Siriwardana, M., 2003. Trade liberalisation in South Asia: Free trade area or customs union? *Journal of South Asian Studies*, 26(3), 59-85.
- Stelder, D., 2005. Where do cities form? A geographical agglomeration model for

Europe. *Journal of Regional Science*, 45(4), 657-679.

Urata, S., Kiyota, K., 2005. The impacts of an East Asia free trade agreement on foreign trade in East Asia. in: Ito, T., Rose, A.K. (Eds.), *International Trade in East Asia: NBER-East Asia Seminar on Economics*, Vol. 14: National Bureau of Economic Research, Inc, pp. 217-252.

Table 1. Summary Statistics of Regions

	Number of regions	Population (thousand)				Regional GDP (mil. US\$)			
		Mean	Median	Min.	Max.	Mean	Median	Min.	Max.
Bangladesh	64	2,169	1,960	334	9,540	943	630	179	11,324
Brunei Darussalam	1	374	374	374	374	6,400	6,400	6,400	6,400
Cambodia	23	600	571	30	1,934	273	172	4	1,423
China	344	3,716	3,107	79	27,980	6,576	3,794	63	106,000
Hong Kong	1	6,838	6,838	6,838	6,838	178,000	178,000	178,000	178,000
India	579	1,897	1,553	34	22,251	1,433	836	7	30,291
Indonesia	435	476	241	0.3	8,821	594	199	0.3	44,328
Japan	47	2,718	1,753	607	12,577	99,952	54,007	18,726	845,000
Korea	16	2,940	1,847	531	10,341	43,815	26,950	10,041	165,000
Laos	17	331	288	87	847	168	107	16	892
Macao	1	473	473	473	473	11,600	11,600	11,600	11,600
Malaysia	14	1,866	1,508	230	4,689	8,446	7,708	765	25,537
Myanmar	14	3,930	4,093	299	7,611	852	762	49	1,608
Philippines	17	5,015	4,025	1,522	11,074	5,806	1,311	172	46,659
Singapore	1	3,544	3,544	3,544	3,544	120,000	120,000	120,000	120,000
Taiwan	25	911	560	10	3,737	13,429	5,219	46	147,000
Thailand	76	857	644	173	6,790	2,318	958	209	56,322
Vietnam	61	1,362	1,138	300	5,481	867	582	60	8,231

Table 2. Parameters for Physical Transport Cost and Time Cost

	Railway	Truck	Sea	Air	Unit	Sources
Physical travel cost per kilometer	0.5	1	0.24	45.2	US\$/km	Map
Travel speed per hour	19.1	38.5	14.7	800	km/hour	Estimation
Holding time for domestic shipping	2.733	0	11.671	9.01	hours	Estimation
Holding time for international shipping	13.224	13.224	14.972	12.813	hours	Estimation
Holding cost for domestic shipping		0	190	690	US\$	Map
Holding cost for international shipping	500	500	504.2	1380.1	US\$	Map

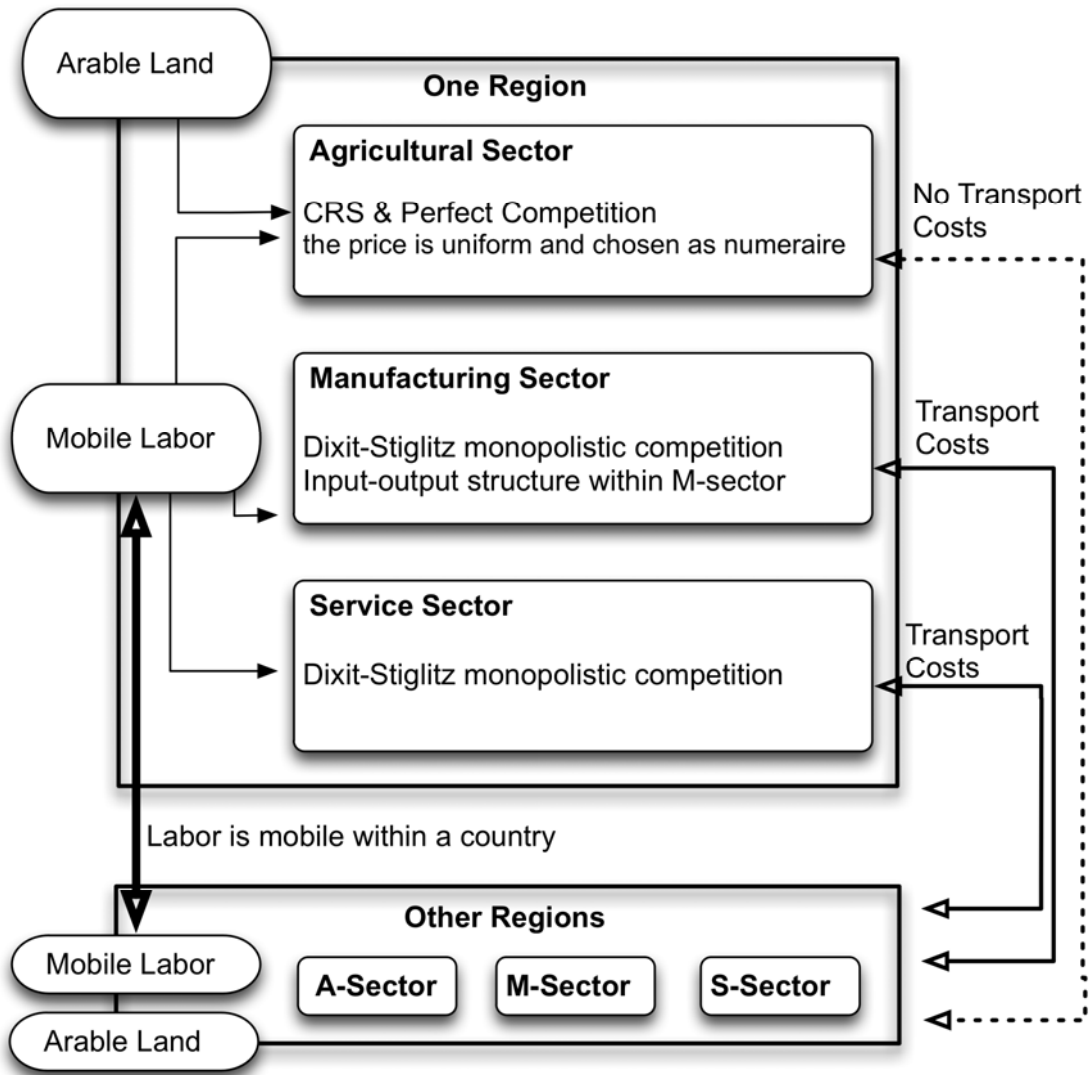
*Note:* “Map” refers to the ASEAN Logistics Network Map 2008 by JETRO, and “Estimation” indicates the estimation of the firm-level transport mode choice using the “Establishment Survey on Innovation and Production Network” (ERIA) for 2008 and 2009.

Table 3. Economic Impact for Regions along MIEC

Scenario	(I) PI+CF	(II) NTB	(III) PI+CF+NTBs	(I) + (II)	(III) - (I) - (II)
Ba Ria-Vung Tau	2.37%	1.42%	3.86%	3.79%	0.07%
Dong Nai	0.51%	3.86%	4.52%	4.37%	0.15%
Ho Chi Minh City	0.20%	2.14%	2.42%	2.34%	0.08%
Svay Rieng	0.31%	1.17%	1.65%	1.48%	0.17%
Kandal	0.43%	1.85%	2.53%	2.28%	0.25%
Phnom Penh	0.00%	1.45%	1.63%	1.44%	0.19%
Kampong Chhnang	1.34%	1.58%	3.18%	2.92%	0.26%
Pursat	1.07%	1.04%	2.31%	2.11%	0.20%
Battambang	2.49%	1.01%	3.75%	3.50%	0.24%
Banteay Meanchey	3.12%	1.17%	4.55%	4.28%	0.27%
Sa Kaeo	0.12%	1.07%	1.23%	1.19%	0.04%
Chachoengsao	0.78%	3.88%	4.90%	4.66%	0.23%
Samut Prakarn	0.93%	3.87%	5.12%	4.81%	0.32%
Bangkok	0.20%	1.52%	1.76%	1.72%	0.05%
Nakhon Pathom	0.72%	2.76%	3.66%	3.49%	0.17%
Kanchanaburi	0.36%	1.36%	1.79%	1.73%	0.07%
Taninthayi	12.40%	0.50%	13.14%	12.89%	0.24%
Average	1.61%	1.86%	3.65%	3.47%	0.18%

Source: Authors' calculation.

Figure 1. Basic Structure of the Model in the Simulation



Source: Compiled by the authors.



Figure 2. Image Diagram: Difference between the Baseline Scenario and Alternative Scenarios

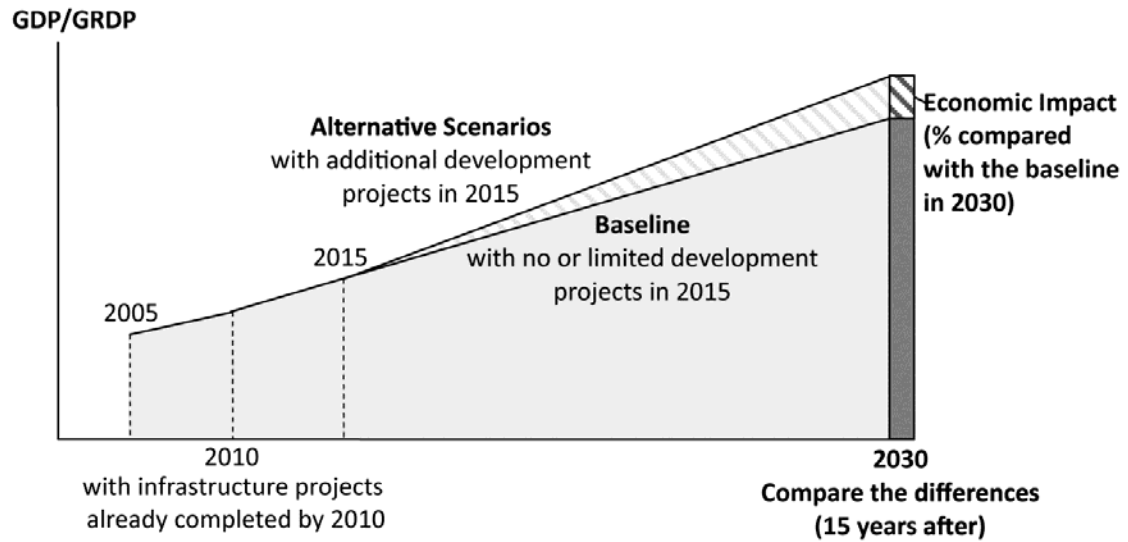
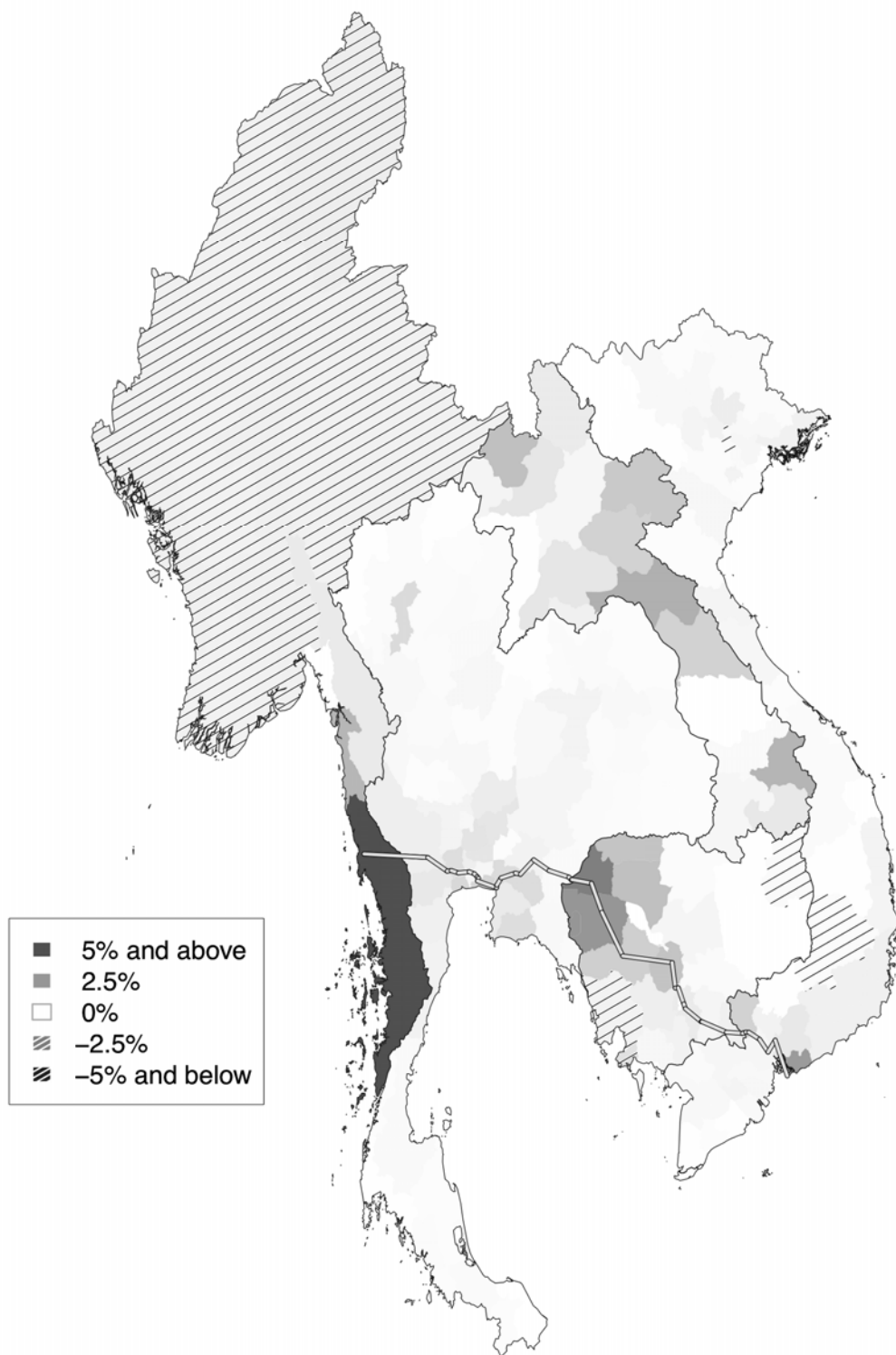
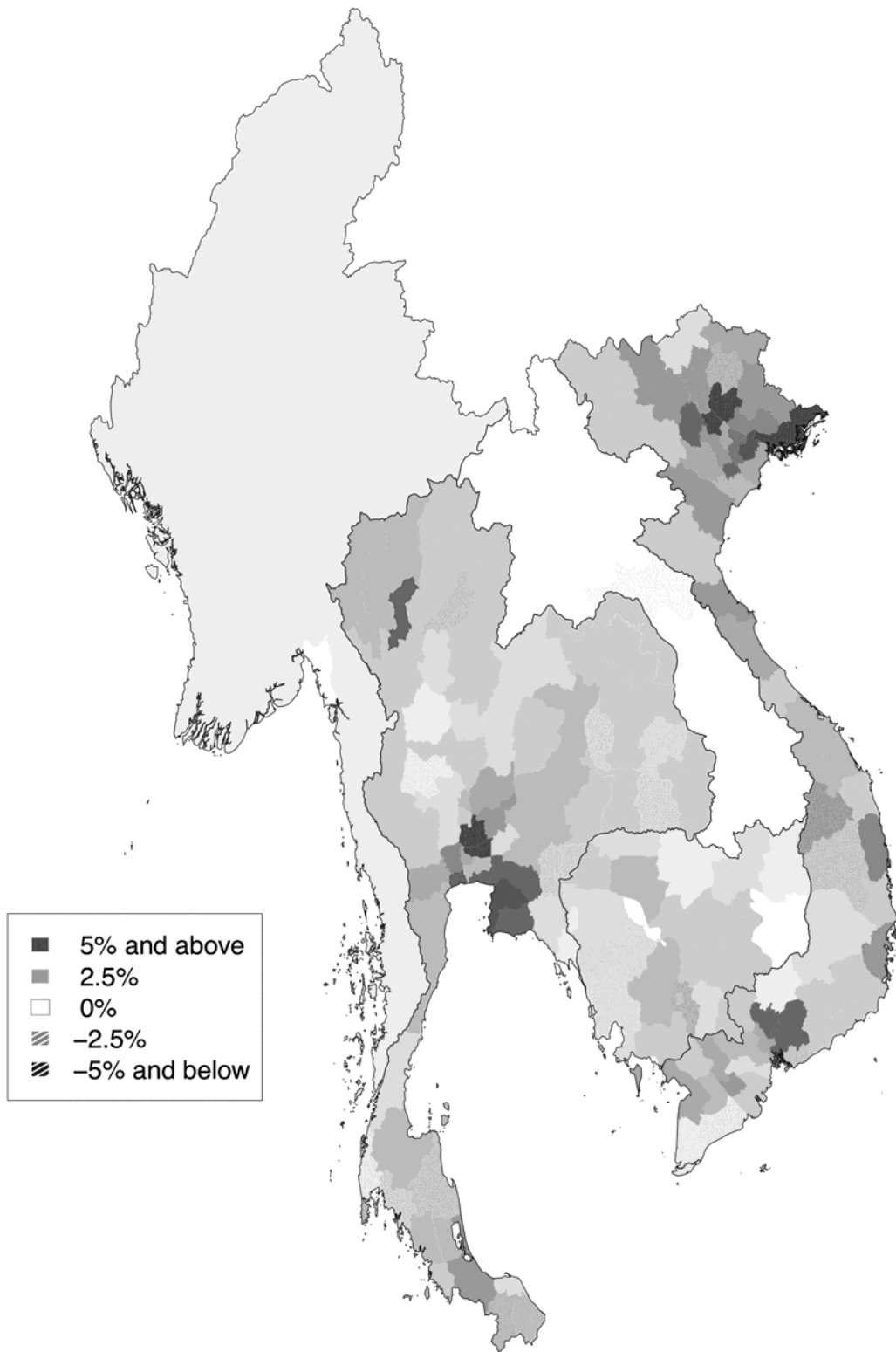


Figure 3. Impact of Physical Infrastructure Development and Customs Facilitation along MIEC



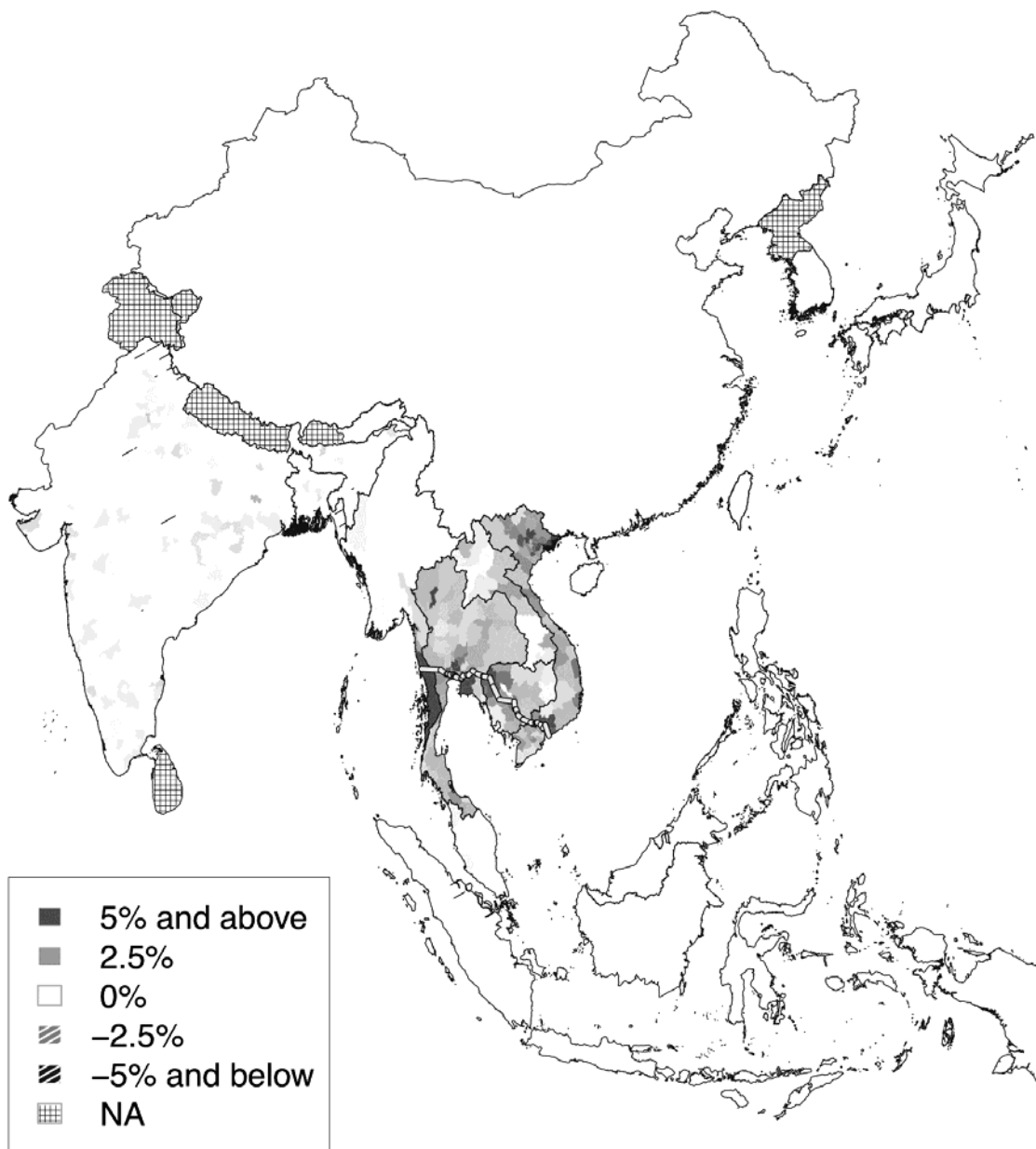
Source: Compiled by the authors.

Figure 4. Impact of Reduction in Non-tariff Barriers in Countries along MIEC



Source: Compiled by the authors.

Figure 5. Impact of Physical Infrastructure Development, Customs Facilitation, and Reduction in Non-tariff Barriers in Countries along MIEC



Source: Compiled by the authors.