Chapter 6

Implications from Geographical Simulation Model Analyses

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Chapter 6

Implications from Geographical Simulation Model Analyses[1]

Maps shown in the study are not to scale. All maps shown in this study are only for demonstrative and study purpose. The shape and boundaries and borders of countries/states shown here do not represent the actual size and shape of countries/states, and the actual size, shape and borders of domestic, national and international boundaries of country/countries shown in the figures/tables/charts and titles.

This paper investigates the expected economic impacts of the development of the Trilateral Highway (TLH) and its eastward extension using the Geographical Simulation Model from the Institute of Developing Economies, Japan External Trade Organization (JETRO) and the Economic Research Institute for ASEAN and East Asia (IDE/ERIA–GSM).

6.1. IDE/ERIA–GSM

Since 2007, IDE–JETRO has been developing the model. The theoretical foundation of the IDE/ERIA–GSM (co-developed with ERIA) follows the New Economic Geography, in particular, Puga and Venables (1996), who captured the characteristics of multi-sector and country general equilibrium.[2]

The IDE/ERIA–GSM includes agriculture, five manufacturing sectors (automotive, electric and electronics, apparel, food processing, and other manufacturing), mining, and the services sector. The model allows workers to move within countries and between sectors with frictions. A notable difference between the IDE/ERIA–GSM and the model proposed by Puga and Venables (1996) lies in the agricultural sector. The IDE/ERIA–GSM explicitly incorporates land size in

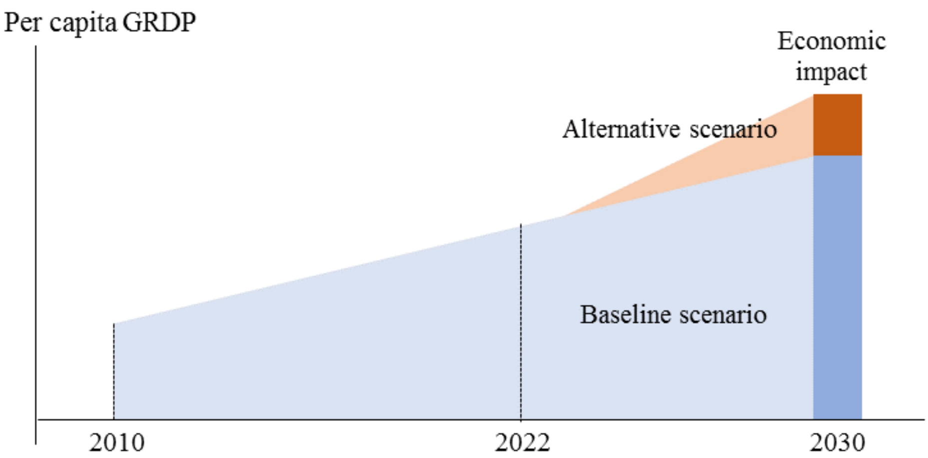
[1] This chapter is based on Umezaki and Kumagai (2020), which is one of background papers for this project

[2] The earlier version of IDE/ERIA–GSM is explained in Kumagai et al. (2013). For further details of the IDE/ERIA–GSM, see Appendix.

agricultural production and keeps its technology as constant returns to scale. This model incorporates the type of physical or institutional integration that will favourably or adversely affect regions of interest. It also incorporates the impact of policy measures to facilitate international transactions on the magnitude and location of trade traffic. These enable identifying potential roadblocks limiting the benefits of economic integration.

Figure 6.1 shows the differences in gross regional domestic product (GRDP) between the baseline and alternate scenarios through calculating the economic impact of various logistics infrastructures. The baseline scenario assumes national and regional growth based on official statistics and international organisation estimations after 2010, while the alternative assumes that several logistics infrastructures (ex. expressways) will be completed by 2022. We compare the GRDP between these two scenarios in 2030. It should be noted that the baseline scenarios have already assumed around 6% growth at the national level. In other words, the negative impacts do not necessarily mean that GRDP of a region or an industry would shrink compared to its current size. Instead, they would be smaller than what they might have expanded to, i.e., the baseline. More precisely, suppose the result predicts that agriculture in region A would be -1% compared to the baseline in 2030. Moreover, suppose the baseline predicts agriculture would expand from 50 to 100, by whatever units, between 2022 and 2030. Out of 50, -1% is 0.2; therefore, it predicts that agriculture would expand from 50 to 99.8 instead of 100 in 2030.

Figure 6.1. Difference between the Baseline and Alternative Scenarios



GRDP = gross regional domestic product.
Source: IDE/ERIA–GSM Team.

6.2. Baseline and Alternative Scenarios

We conduct a simulation analysis of the following five alternative scenarios. In IDE/ERIA–GSM, the quality of road infrastructure is categorised into four classes in terms of average speed to connect one point with another. The average speed on road segments with standard quality is set at 38.5 km/h.[3] The status quo of the road infrastructure is classified with reference to the recent assessment of the Greater Mekong Subregion (GMS) Economic Corridors by ADB (ADB 2018a-h). Basically, the average speed on the road segments with Class III or below, and/or those in 'poor' conditions, is set at 19 km/h. In addition, each of the five scenarios is simulated in two stages in terms of the quality of road infrastructure; the first stage (average speed of 38.5 km/h) represents 'moderate improvement', and the second stage (average speed of 60.0km/h) represents 'significant improvement'.[4]

Based on the updated information on the TLH and its potential extension routes, the baseline scenario was set as follows. Along the original alignment of the TLH, road sections under 'poor' quality, which are classified as '2' in the model as of 2020, are: (i) Kalewa–Yargyi (115km); (ii) Thaton–Hpa-An (51km); (iii) Hpa-An–Eindu (20km); and (iv) Eindu–Kawkareik (71km). Road sections under 'poor' quality along the eastward extension routes are: (v) Payangazu–Kalaw (76km); (vi) Taunggyi–Loilem (91km); (vii) Loilem–Ta Kaw (177km); (viii) Ta Kaw–Keng Tong (190km); (ix) Tarlay–Keng Lap (56km); (x) Xieng Kok–Muang Sing (69km) in Lao People's Democratic Republic (Lao PDR); and (xi) Tay Trang–Na Thin (19.2km) in Viet Nam. Except for (x) and (xi), all 'poor' quality sections are in Myanmar. In addition, reflecting the fact that the Myanmar–Lao PDR Friendship Bridge, that is, the border between Keng Lap in Myanmar and Xieng Kok in Lao PDR, is yet to be fully utilised as an international border gate, we set the baseline that Myanmar can use the bridge only for transit export to China, Viet Nam, and Thailand via Lao PDR, meaning that Myanmar cannot export to Lao PDR through the bridge. In addition, Myanmar cannot import through the bridge wherever origin countries are. These are the elements of the status quo.

[3] For more details, see Table A5 in the Appendix. The four classes are (1) very poor [walking speed: 4km/h], (2) poor [19km/h], (3) standard [38.5km/h], and (4) highway quality [60km/h].

[4] Although 'significant improvement' is expected to generate larger economic impacts, it will cost much more than 'moderate improvement'. It is a fundamental tenet of the policy domain to determine the quality of infrastructure improvements by comparing the expected benefits and costs.

Scenario 1 **On-time completion of ongoing road infrastructure projects**

Most of the 'poor' quality sections are already being upgraded with specific timelines for completion. The information on the design standard and timeline is already reflected in the alternative scenarios. Specifically, the following are included in this scenario.

- [Myanmar] Kalewa–Yargyi section will be upgraded (2 → 3) in 2022 and beyond, reflecting the fact that the work is planned to be completed in May 2021.
- [Myanmar] Bago–Payagyi–Kyaikhto section will be upgraded (3 → 4) in 2025 and beyond, reflecting the fact that the bypass road is planned to be completed in December 2024.
- [Myanmar] Thaton–Hpa-An–Eindu section will be upgraded to (2 → 3) in 2025 and beyond reflecting the ongoing and planned upgrading work by ADB and Thailand.
- [Myanmar] Eindu–Kawkareik section will be upgraded (2 → 3) in 2021 and beyond, reflecting the fact that the road improvement will be completed in March 2020 and the Gyaing Kawkareik Bridge is planned to be completed in May 2021.
- [India = Myanmar] Improvements in border crossing procedures at Moreh = Tamu border in 2021 and beyond.
- [Myanmar = Thailand] Improvements in border crossing procedures at Myawaddy = Mae Sot border in 2021 and beyond.

Scenario 2a **Eastward extension (Northern route)**

- Scenario 1 inclusive.
- [Myanmar] Payangazu–Kalaw section will be upgraded (2 → 3) in 2021 and beyond, based on the observation of ongoing improvement work.
- [Myanmar] Taunggyi–Loilen–Takaw–Kentung section will be upgraded (2 → 3) in 2025 and beyond. As of December 2019, foreigners' entry into this section is restricted for security reasons. However, in order to activate this extension route, normalisation of this section is necessary.
- [Myanmar] Tarlay–Keng Lap section will be improved (2 → 3) in 2025 and beyond. Brownfield investment in this section has been listed in the Initial Rolling Pipeline of Potential ASEAN

Infrastructure Projects (Initial Pipeline) under the Master Plan on ASEAN Connectivity 2025 (World Bank et al., 2019).[5]

- [Lao PDR] Xieng Kok–Muang Sing section will be upgraded (2 → 3) in 2025 and beyond.
- [Viet Nam] Tay Trang–Na Thin section in Viet Nam will be upgraded (2 → 3) in 2021 and beyond, reflecting the ongoing repair and improvement works.
- [Lao PDR = Viet Nam] Improvements in border crossing procedures at Pang Hoc = Tay Trang border in 2021 and beyond.

Scenario 2b **Eastward extension (Northern route) + internationalisation of the Myanmar–Lao Friendship Bridge**

- Scenario 2a inclusive.
- [Myanmar = Lao PDR] Internationalisation of the Myanmar–Lao Friendship Bridge at Kyainglat = Xieng Kok border in 2021 and beyond, by removing specific settings in the baseline scenario to allow international trade between Myanmar and Lao PDR, including transit trade via each other, in the same way as other border points.

Scenario 3 **Eastward extension (Southern route)**

- Scenario 1 inclusive.
- [Thailand = Cambodia] Improvements in border crossing procedures at Ban Khlong Luek = Poipet border in 2021 and beyond.
- [Cambodia = Viet Nam] Improvements in border crossing procedures at Bavet = Moc Bai border in 2021 and beyond.

Scenario 4a **All**

- Scenario 2b inclusive.

[5] According to World Bank et al. (2019), '(t)his project is at an early stage of development and it is understood that no studies on the project have been carried out to date, ' as of November 2019.

- Scenario 3 inclusive.

Scenario 4b **All (challenging)**

- Scenario 4a inclusive.
- [All] Upgrade all TLH and eastward extension sections to 'highway quality' (3 → 4), enabling trucks to drive at 60 km/h on average.

6.3. Simulation Results and Implications

(1) By Countries

The simulation results are shown in Figures 6.2 and 6.3. Tables 6.1 to 6.6 illustrate more details of the results of scenarios S1 to S4b respectively. At first glance, several characteristics can be pointed out. First, the impacts on India and Thailand are much smaller than those on Myanmar, both in terms of the difference in the value (Figure 6.2) and percentage (Figure 6.3), as would be expected since most of the TLH is in Myanmar. Second, the internationalisation impact of the Myanmar–Lao Friendship Bridge is very small, indicating that the potential demand for transportation crossing the border is limited. Relating to this, the expected impact on Lao PDR is small. Third, comparison of S4a and S4b shows that the better the quality of the road, the larger the impacts are. Fourth, the expected impacts on Cambodia and Viet Nam depend on the choice of the extension routes.

Scenario 1 (S1), together with the completion of the ongoing projects and improvements in border crossing procedures at Moreh = Tamu and Myawaddy = Mae Sot borders, implies the completion of the original alignment of the TLH. Under this scenario, Myanmar's gross domestic product (GDP) is expected to increase by 0.12% compared to the baseline in 2035, while the impacts on India and Thailand are also positive but very small. Reflecting the original alignment of the TLH, in which almost all road segments are in its territory, Myanmar is expected to enjoy most of the gains, amounting to 74.9% of the increase in GDP in the three countries, while Thailand and India share 22.0% and 3.1% respectively. Thailand and India have already invested in the construction of roads along the TLH. First, Thailand aided Myanmar to construct the bypass road between Myawaddy and Kawkareik, which used to be the most significant bottleneck for the road connectivity between Myanmar and Thailand. In addition, Thailand 'agreed to shoulder the B1.8 billion (US$52 million) cost for improving a 68 km road linking the towns of Eindu and Thaton in southern Myanmar.'[6] India has been assisting Myanmar in the construction of the Kalewa–Yargyi section of the TLH. It is important for each member of the trilateral cooperation to pay appropriate attention to the balance between the cost and benefit related to the TLH.

The impacts of the eastward extension routes differ significantly by country and by the choice of the route. The overall impact is larger in the case of northern route (S2b), where the total GDP gain in India, Myanmar, and Thailand amounts to US$677 million (Table 6.3), US$168 million more than the comparable figure for the southern route (S3) (Table 6.4). Myanmar will capture most of the gains in both cases. As expected, the southern route will benefit Cambodia and Viet Nam, while the expected benefit for Lao PDR is very small, even in the case of the northern route. The difference between the results of S1b and S1a shows that the impact of internationalisation of the Myanmar–Lao Friendship Bridge is marginal, implying that the potential demand for trade across Kyainglat = Xieng Kok border is limited. According to the World Bank, et al. (2019), the estimated cost for improving the Tarlay–Kyainglat section (56 km) is US$71 million. It could cost more to pave the 69 km earthen section between Xieng Kok and Muang Sing in Lao PDR. Again, it is important for Myanmar and Lao PDR to examine deliberately the balance of costs and benefits to realise this scenario (S2b).

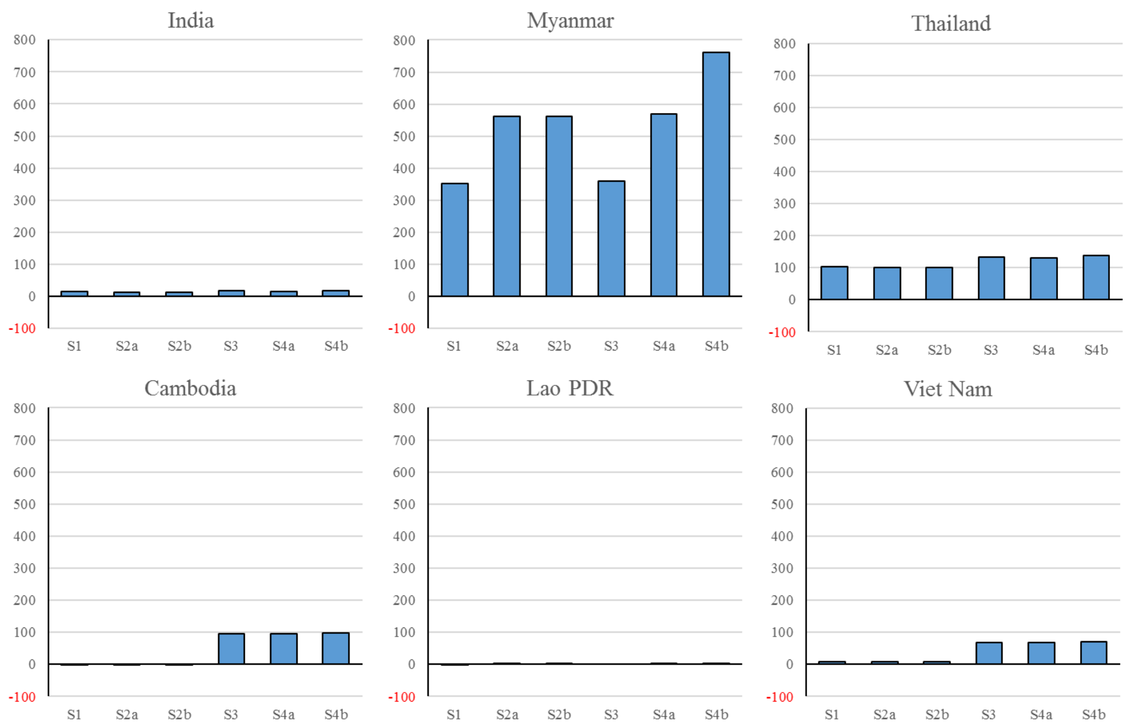
Tables 6.3 and 6.4 allow us to compare the expected benefits of the two potential routes for the eastward extension. The total gains of the six countries (India, Myanmar, Thailand, Cambodia, Lao PDR, and Viet Nam) are slightly larger in the case of the northern route (S2b, US$686 million) than the southern route (S3, US$674 million). However, the distribution of the benefits is different. As mentioned above, the total expected gain for India, Myanmar, and Thailand in S2b is US$677 million, which shares 98.7% of the total gain for the six countries. That is, the expected gains for Cambodia, Lao PDR, and Viet Nam amount only to US$9 million (1.3%). In contrast, the southern extension route will benefit Cambodia and Viet Nam significantly, US$97 million and US$68 million respectively (Table 6.4). That is, the southern route is preferable for Cambodia and Viet Nam and, to a lesser extent, Lao PDR, than the northern route. In addition, expected impacts of the northern and southern routes need to be compared taking the necessary costs into

[6] 'Thailand to Support Upgrade of Key Road Link in Southern Myanmar,' Greater Mekong Subregion Secretariat, 5 September 2018.

account. The southern route does not require additional costs to improve road infrastructure on the extension parts, because the road sections are already in better condition than those on the northern extension route. Even though the total expected gains for the six countries are slightly larger in the northern route (S2b), it could cost significantly more than the southern route (S3). Another important point is the expected impacts on Myanmar, which is US$562 million in S2b, in contrast to US$358 million in S3. Indeed, if we compare the expected gains in GDP, the northern route is preferable only for Myanmar amongst the six countries.

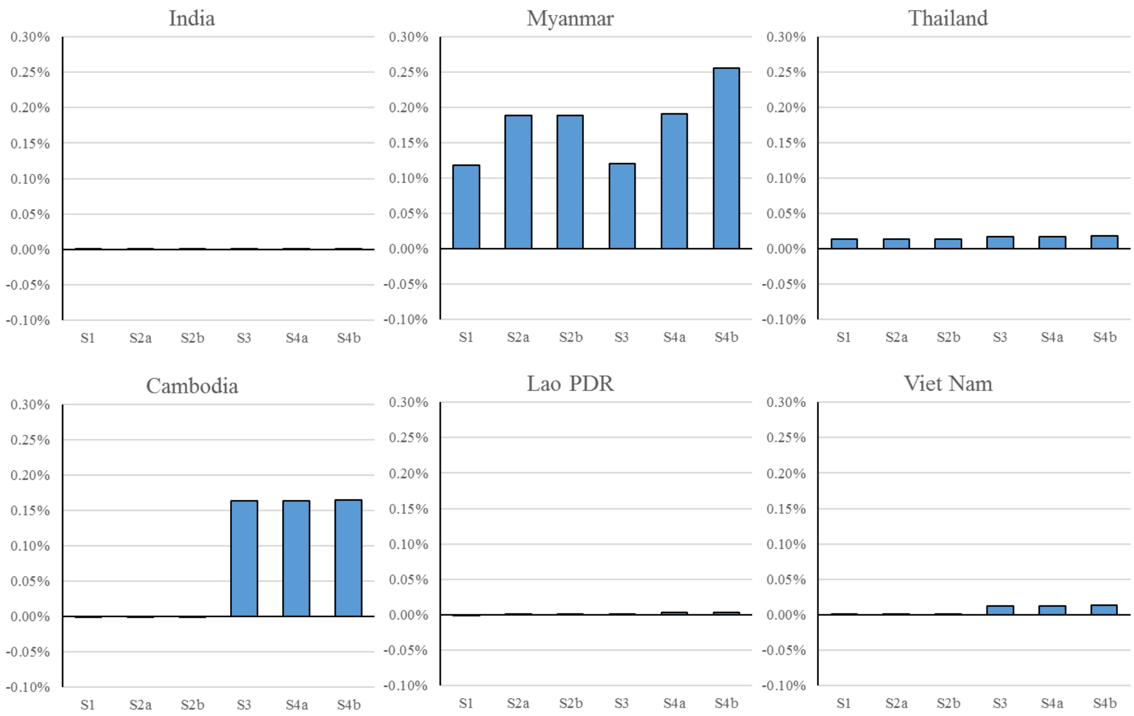
It is natural to expect the highest gains in the case of the 'all' development scenario (S4a), which includes both the northern and southern routes in addition to the original alignment of the TLH (Table 6.5). The additional scenario (S4b) to upgrade all routes to highway standard is expected to magnify the impacts to all six countries (Table 6.6). Again, these results need to be evaluated together with the cost consideration.

Figure 6.2. Impacts by Countries (difference in US$ millions vs. Baseline)



Lao PDR = Lao People's Democratic Republic, US$ = US dollars.
Source: Estimated by IDE/ERIA–GSM Team.

Figure 6.3. Impacts by Countries (% difference vs. Baseline)



Lao PDR = Lao People's Democratic Republic.
Source: Estimated by IDE/ERIA–GSM Team.

Table 6.1. Results of S1 by Countries and Industries (in US$ millions)

	Agriculture	Automotive	Electrics and Electronics	Textile	Food Processing	Other Manufacturing	Services	Mining	Real GDP
India	23.51	▼ 0.86	0.05	▼ 0.06	▼ 2.35	▼ 5.57	▼ 0.41	0.07	14.39
Myanmar	5.04	9.79	1.19	1.32	372.44	8.51	▼ 46.78	0.06	351.56
Thailand	2.98	▼ 1.38	▼ 0.58	2.28	100.78	▼ 3.12	2.33	▼ 0.04	103.25
Cambodia	0.03	0.00	0.00	0.10	▼ 0.43	0.01	0.07	0.00	▼ 0.21
Lao PDR	▼ 0.00	0.00	▼ 0.00	0.00	▼ 0.31	▼ 0.00	0.19	▼ 0.00	▼ 0.12
Viet Nam	0.55	▼ 0.00	0.01	0.26	7.70	0.07	0.03	0.00	8.63
China	▼ 0.31	▼ 0.94	▼ 1.66	0.56	▼ 37.07	5.00	0.46	0.42	▼ 33.54
Japan	0.07	▼ 0.91	▼ 0.29	▼ 0.03	▼ 3.26	▼ 2.16	19.18	▼ 0.00	12.61
IMT	31.53	7.55	0.66	3.54	470.87	▼ 0.18	▼ 44.86	0.09	469.20
IMT+CLV	32.11	7.55	0.68	3.91	477.83	▼ 0.10	▼ 44.56	0.09	477.50
ASEAN10	8.72	8.66	0.06	4.05	484.06	4.41	▼ 36.34	0.02	473.63
EA16	32.21	5.94	▼ 1.31	4.59	439.77	▼ 0.81	▼ 2.80	0.48	478.05

CLV = Cambodia, Lao PDR, and Viet Nam; GDP = gross domestic product; IMT = India, Myanmar, Thailand; ASEAN10 = 10 ASEAN Member States; EA16 = ASEAN10 + Australia, China, India, Japan, Republic of Korea, and New Zealand; Lao PDR = Lao People's Democratic Republic.
Source: Estimated by IDE/ERIA–GSM Team.

Table 6.2. Results of S2a by Countries and Industries (in US$ millions)

	Agriculture	Automotive	Electrics and Electronics	Textile	Food Processing	Other Manufacturing	Services	Mining	Real GDP
India	24.08	▼ 1.22	0.00	▼ 0.13	▼ 2.93	▼ 5.04	▼ 1.18	0.07	13.64
Myanmar	14.58	7.34	1.11	1.01	294.24	0.54	242.70	0.05	561.56
Thailand	3.13	▼ 1.36	▼ 0.58	2.36	98.74	▼ 3.16	2.21	▼ 0.02	101.32
Cambodia	0.03	0.00	0.00	0.10	▼ 0.42	0.01	0.06	0.00	▼ 0.21
Lao PDR	0.05	▼ 0.01	▼ 0.01	▼ 0.06	0.01	▼ 0.24	0.26	0.36	0.37
Viet Nam	0.57	0.00	0.01	0.39	7.74	0.05	0.02	0.14	8.92
China	0.36	0.02	▼ 1.31	0.50	▼ 38.23	7.41	▼ 0.28	0.54	▼ 31.00
Japan	0.15	▼ 0.85	▼ 0.30	▼ 0.04	▼ 3.00	▼ 2.14	16.81	▼ 0.00	10.63
IMT	41.79	4.76	0.53	3.24	390.05	▼ 7.67	243.73	0.10	676.51
IMT+CLV	42.44	4.75	0.53	3.67	397.38	▼ 7.84	244.07	0.60	685.60
ASEAN10	18.54	6.28	▼ 0.03	3.89	404.14	▼ 3.88	252.67	0.54	682.15
EA16	43.36	4.22	▼ 1.13	4.26	357.44	▼ 6.05	280.81	1.12	684.03

CLV = Cambodia, Lao PDR, and Viet Nam; GDP = gross domestic product; IMT = India, Myanmar, Thailand; ASEAN10 = 10 ASEAN Member States; EA16 = ASEAN10 + Australia, China, India, Japan, Republic of Korea, and New Zealand; Lao PDR = Lao People's Democratic Republic.
Source: Estimated by IDE/ERIA–GSM Team.

Table 6.3. Results of S2b by Countries and Industries (in US$ millions)

	Agriculture	Automotive	Electrics and Electronics	Textile	Food Processing	Other Manufacturing	Services	Mining	Real GDP
India	24.08	▼ 1.22	0.00	▼ 0.13	▼ 2.93	▼ 5.05	▼ 1.18	0.07	13.63
Myanmar	14.58	7.34	1.11	1.01	294.27	0.53	242.69	0.05	561.59
Thailand	3.13	▼ 1.36	▼ 0.58	2.36	98.74	▼ 3.16	2.21	▼ 0.02	101.31
Cambodia	0.03	0.00	0.00	0.10	▼ 0.42	0.01	0.06	0.00	▼ 0.21
Lao PDR	0.05	▼ 0.01	▼ 0.01	▼ 0.06	0.01	▼ 0.24	0.27	0.36	0.37
Viet Nam	0.57	0.00	0.01	0.39	7.78	0.05	0.02	0.15	8.96
China	0.36	0.02	▼ 1.31	0.50	▼ 38.24	7.41	▼ 0.28	0.54	▼ 31.01
Japan	0.15	▼ 0.85	▼ 0.30	▼ 0.04	▼ 3.00	▼ 2.14	16.81	▼ 0.00	10.63
IMT	41.79	4.76	0.53	3.24	390.07	▼ 7.67	243.72	0.10	676.53
IMT+CLV	42.44	4.75	0.53	3.67	397.44	▼ 7.85	244.08	0.60	685.66
ASEAN10	18.54	6.28	▼ 0.03	3.89	404.20	▼ 3.89	252.68	0.54	682.22
EA16	43.36	4.22	▼ 1.13	4.26	357.49	▼ 6.05	280.82	1.13	684.09

CLV = Cambodia, Lao PDR, and Viet Nam; GDP = gross domestic product; IMT = India, Myanmar, Thailand; ASEAN10 = 10 ASEAN Member States; EA16 = ASEAN10 + Australia, China, India, Japan, Republic of Korea, and New Zealand; Lao PDR = Lao People's Democratic Republic.

Source: Estimated by IDE/ERIA–GSM Team.

Table 6.4. Results of S3 by Countries and Industries (in US$ millions)

	Agriculture	Automotive	Electrics and Electronics	Textile	Food Processing	Other Manufacturing	Services	Mining	Real GDP
India	23.82	▼ 1.11	0.58	▼ 0.79	▼ 2.95	▼ 4.51	1.78	0.10	16.93
Myanmar	5.27	9.65	1.17	1.32	379.79	8.21	▼ 46.99	0.06	358.47
Thailand	8.17	5.17	▼ 1.67	17.67	109.07	▼ 7.97	2.76	0.01	133.20
Cambodia	4.68	2.07	0.31	73.16	19.00	2.92	▼ 5.53	0.02	96.64
Lao PDR	0.01	▼ 0.02	▼ 0.01	▼ 0.08	0.49	▼ 0.08	0.23	0.01	0.54
Viet Nam	5.73	3.54	0.37	20.19	37.57	3.30	▼ 2.96	0.12	67.86
China	2.99	▼ 3.65	▼ 0.51	▼ 16.94	▼ 42.01	15.92	▼ 0.21	0.53	▼ 43.88
Japan	0.13	▼ 0.44	0.21	▼ 0.54	▼ 3.33	▼ 0.85	21.26	▼ 0.00	16.43
IMT	37.25	13.71	0.08	18.20	485.91	▼ 4.27	▼ 42.45	0.17	508.60
IMT+CLV	47.68	19.30	0.76	111.47	542.97	1.86	▼ 50.71	0.32	673.64
ASEAN10	24.29	19.88	0.06	111.46	549.68	6.21	▼ 44.23	0.23	667.57
EA16	51.79	14.05	1.19	92.80	499.57	14.71	▼ 4.63	0.86	670.34

CLV = Cambodia, Lao PDR, and Viet Nam; GDP = gross domestic product; IMT = India, Myanmar, Thailand; ASEAN10 = 10 ASEAN Member States; EA16 = ASEAN10 + Australia, China, India, Japan, Republic of Korea, and New Zealand; Lao PDR = Lao People's Democratic Republic.
Source: Estimated by IDE/ERIA–GSM Team.

Table 6.5. Results of S4a by Countries and Industries (in US$ millions)

	Agriculture	Automotive	Electrics and Electronics	Textile	Food Processing	Other Manufacturing	Services	Mining	Real GDP
India	24.38	▼ 1.48	0.53	▼ 0.86	▼ 3.52	▼ 3.99	1.01	0.09	16.17
Myanmar	14.81	7.20	1.08	1.01	301.61	0.23	242.48	0.05	568.48
Thailand	8.32	5.20	▼ 1.67	17.74	107.03	▼ 8.01	2.64	0.03	131.27
Cambodia	4.68	2.07	0.31	73.16	19.02	2.92	▼ 5.54	0.02	96.64
Lao PDR	0.06	▼ 0.03	▼ 0.02	▼ 0.13	0.70	▼ 0.31	0.32	0.37	0.96
Viet Nam	5.75	3.54	0.37	20.31	37.58	3.28	▼ 2.97	0.26	68.12
China	3.65	▼ 2.70	▼ 0.17	▼ 17.01	▼ 43.17	18.32	▼ 0.94	0.65	▼ 41.35
Japan	0.20	▼ 0.38	0.20	▼ 0.55	▼ 3.08	▼ 0.83	18.88	▼ 0.00	14.45
IMT	47.51	10.92	▼ 0.05	17.89	405.12	▼ 11.76	246.13	0.18	715.93
IMT+CLV	58.00	16.50	0.61	111.23	462.41	▼ 5.88	237.94	0.82	881.64
ASEAN10	34.11	17.50	▼ 0.03	111.30	469.66	▼ 2.08	244.79	0.75	876.01
EA16	62.93	12.33	1.37	92.48	417.13	9.47	278.99	1.50	876.21

CLV = Cambodia, Lao PDR, and Viet Nam; GDP = gross domestic product; IMT = India, Myanmar, Thailand; ASEAN10 = 10 ASEAN Member States; EA16 = ASEAN10 + Australia, China, India, Japan, Republic of Korea, and New Zealand; Lao PDR = Lao People's Democratic Republic.
Source: Estimated by IDE/ERIA–GSM Team.

Table 6.6. Results of S4b by Countries and Industries (in US$ millions)

	Agriculture	Automotive	Electrics and Electronics	Textile	Food Processing	Other Manufacturing	Services	Mining	Real GDP
India	25.49	▼ 1.62	0.52	▼ 0.90	▼ 3.96	▼ 4.12	1.04	0.11	16.57
Myanmar	19.66	5.90	1.27	1.05	306.42	▼ 1.60	428.76	0.05	761.52
Thailand	8.52	5.13	▼ 1.65	17.93	112.44	▼ 8.33	3.05	0.03	137.12
Cambodia	4.70	2.08	0.32	73.45	19.06	2.93	▼ 5.52	0.02	97.04
Lao PDR	0.06	▼ 0.03	▼ 0.02	▼ 0.13	0.69	▼ 0.31	0.34	0.37	0.96
Viet Nam	5.81	3.57	0.43	20.48	38.35	3.86	▼ 3.07	0.26	69.68
China	3.84	▼ 2.35	▼ 0.49	▼ 17.09	▼ 45.90	19.29	▼ 1.33	0.75	▼ 43.27
Japan	0.23	▼ 0.55	0.03	▼ 0.58	▼ 3.32	▼ 1.64	20.78	▼ 0.00	14.94
IMT	53.67	9.41	0.15	18.08	414.90	▼ 14.05	432.86	0.19	915.21
IMT+CLV	64.25	15.03	0.87	111.88	473.00	▼ 7.58	424.61	0.84	1082.90
ASEAN10	39.29	16.16	0.13	111.97	481.02	▼ 3.96	432.64	0.76	1078.02
EA16	69.47	11.03	1.05	92.98	424.84	7.30	469.10	1.62	1077.40

CLV = Cambodia, Lao PDR, and Viet Nam; GDP = gross domestic product; IMT = India, Myanmar, Thailand; ASEAN10 = 10 ASEAN Member States; EA16 = ASEAN10 + Australia, China, India, Japan, Republic of Korea, and New Zealand; Lao PDR = Lao People's Democratic Republic.
Source: Estimated by IDE/ERIA–GSM Team.

(2) By Countries and Industries

As shown in Table 6.1, the completion of the original TLH (S1) is expected to increase real GDP of India, Myanmar, and Thailand by US$14.4 million, US$351.6 million, and US$103.2 million, respectively, against the baseline in 2035. As discussed above, Myanmar will gain most of the benefits, and the increment is equivalent to 0.12% of the baseline GDP. The positive impact is driven mainly by the manufacturing sector (US$93.2 million), of which food processing (US$372.4 million) plays a major role. The expected decline in the service sector (▼US$46.8 million) will offset the gain to some extent. Thailand will be the second-largest beneficiary (US$103.2 million) led mainly by the growth of the food processing sector (US$100.8 million), whereas other manufacturing (▼US$3.1 million), automotive (▼US$1.4 million), and electrics and electronics (▼US$0.6 million) sectors are expected to lose slightly in comparison with the baseline. Although the impact on India is limited, agriculture is expected to gain the most (US$23.5 million), part of which will be offset by the expected decline in manufacturing (▼US$8.8 million). The expected impacts on Cambodia and Lao PDR are negative, though the size is small. The improvement in logistics infrastructure, as specified in S1, increases the attractiveness of Myanmar as a trade partner relative to Cambodia and Lao PDR. In this line of discussion, China benefits the least in S1, with its real GDP expected to decrease US$33.5 million from the baseline in 2035. Most of the negative impacts are found in food processing (▼US$37.1

million), probably in exchange for the growth of the industry in Myanmar and Thailand as mentioned above.

The northern extension route (S2b) is expected to increase the impacts of the original TLH (S1) in Myanmar by 59.7% from US$351.6 million to US$561.6 million (Tables 6.1 and 6.3). Lao PDR and Viet Nam will gain, but the impacts are small. In this scenario, Thailand (US$101.3 million) is second-largest beneficiary after Myanmar, and India (US$13.6 million) follows; the positive impacts are slightly smaller than the case of S1. Although a major part of the expected gains in Myanmar is attributable to food processing (52.4%), in this scenario, the service sector will contribute significantly (43.2%, or US$242.7 million). This is a striking contrast with S1, under which the service sector is expected to decline by US$46.8 million (Table 6.1). The positive impact on India is contributed mainly by agriculture (176.5%), a large part of which will be offset by negative impacts on manufacturing and the service sector. The impact of the northern extension route on Cambodia is negligible. Although China will be negatively affected, the impact is smaller than in the original TLH (S1), probably because some of the negative impacts of the original TLH can be offset by the positive effects of enhanced connectivity along the extension route.

The southern extension route also magnifies the impacts of the original TLH but in a different way from the northern extension route (Table 6.4). The additional impacts on India, Myanmar, and Thailand are all positive, but in favour of India and Thailand. Compared with S1 (Table 6.1), India, Myanmar, and Thailand will gain 17.7%, 2.0%, and 29.0%, respectively. This result is quite reasonable in the sense that the southern extension route connects the TLH effectively with the GMS economic corridors, which are already developed more than the northern route. As illustrated in Figure 1-1, the section between Mae Sot and Tak is a part of the East–West Economic Corridor, the section between Tak and Bangkok is a part of the North–South Economic Corridor (NSEC), and the remaining sections are on the Southern Economic Corridor. There used to be several bottlenecks along these corridors, such as the road section between Poipet and Sisophon, and the lack of a bridge over the Mekong River in Neak Loung. Under the GMS Economic Cooperation Program, these bottlenecks have already been removed by improvement of the road and the construction of Tsubasa Bridge. Cambodia will gain an additional US$96.6 million over the baseline in 2035, at the expense of Lao PDR, which will benefit only a small amount (US$500,000). Viet Nam is expected to be the fourth-largest beneficiary (US$67.9

million) after Myanmar (US$358.5 million), Thailand (US$133.2 million) and Cambodia. The total gain of all six countries amounts to US$673.6 million, slightly less than the case of the northern extension route (US$685.7 million). However, the distribution of the gains differs significantly. Only Myanmar would prefer the northern extension route to the southern extension route, and Thailand, Cambodia, and Viet Nam would prefer the southern extension route. For Lao PDR, the expected impacts of the eastward extension routes, both northern and southern, are very small and the difference is negligible. In this case, a cost–benefit consideration may lead Lao PDR not to invest in upgrading the northern extension route, because it would incur costs for which the expected benefit is small. Again from a regional perspective, it should be recalled that the costs for road improvement will be smaller in the case of the southern extension route because most of necessary improvements have already been done.

Tables 6.5 and 6.6 show the simulation results of the most comprehensive scenario in this study, which includes the completion of the original TLH, the northern extension route, and the southern extension route. An important implication of this scenario is that distributional concerns regarding S2b and S3 can be mitigated significantly.

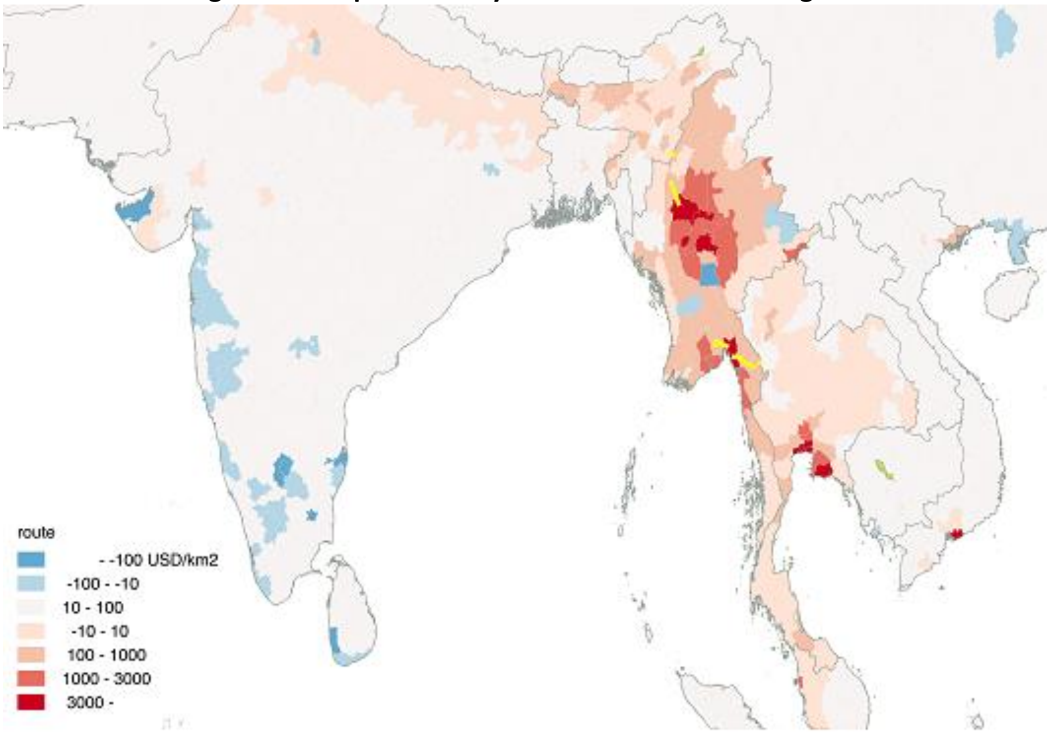
The distributional implications across sectors are roughly the same for all scenarios. The additional growth in Myanmar will be supported by food processing, and the contribution of the service sector is significant only when the northern extension route is developed. Despite the overall benefits, Indian manufacturing may be negatively affected. In contrast, manufacturing in Myanmar and Thailand is expected to gain. Cambodia will also expand its manufacturing, led mainly by the textile sector.

(3) By Subnational Regions

A major benefit of IDE/ERIA–GSM is that it can estimate economic impacts on a subnational level. This section illustrates the simulation results of scenarios 1 to 4b. At first glance, two important implications can be drawn from Figures 6.4 to 6.9. First, the economic impacts are unevenly distributed in favour of the regions along the road to be upgraded. In contrast, other regions may be negatively affected in terms of the difference with the baseline scenario. Second, the economic impacts are expected to spread to wider regions far beyond the scope of logistics enhancement.

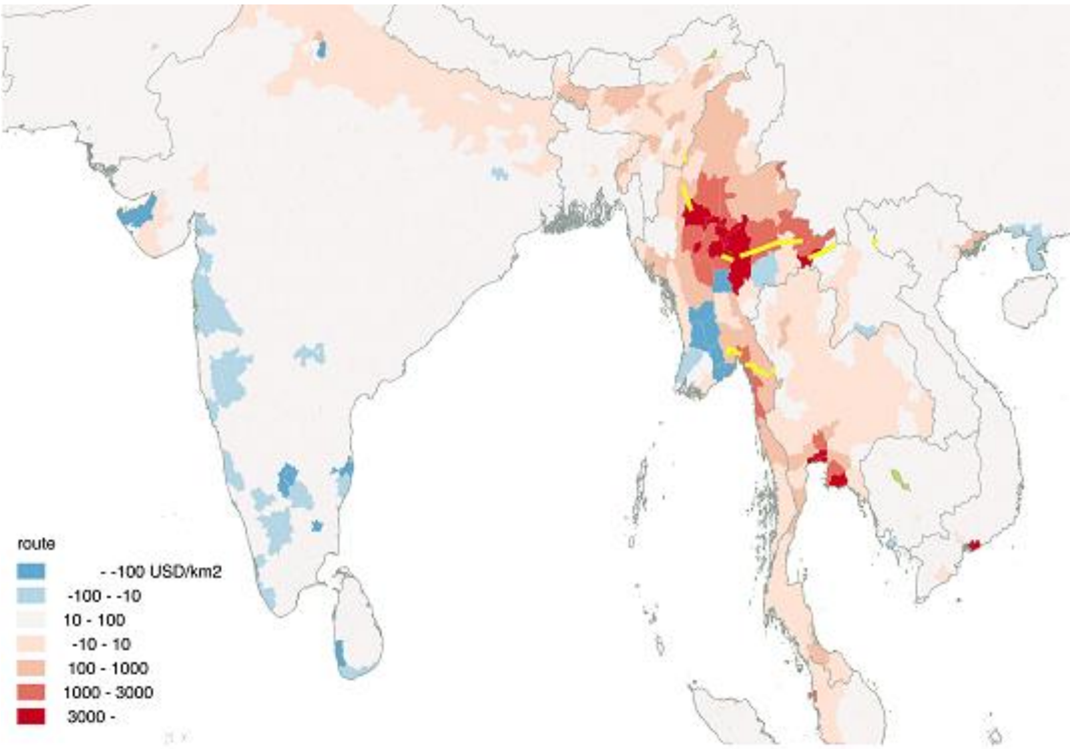
As discussed above, the completion of the original TLH (S1) will increase Myanmar's real GDP by US$351.6 million in comparison with the baseline. Looking at the impact density, which is defined as the economic impacts in US$ terms per km^2, Mandalay gains most (US$29,239/$km^2$), followed by Nyaung-U (US$8,190/$km^2$), Monywa (US$4,699/km^2), Sagain (US$3,937/$km^2$), and Meiktila (US$3,798/km^2). All these provinces are along the TLH and in the central dry zone. In contrast, Nay Pyi Taw will be negatively affected most significantly (▼US$3,647/$km^2$), probably because several economic activities are attracted to Mandalay and surrounding provinces where business environments will be improved particularly from logistic perspectives. In addition, Pyay (▼US$34/$km^2$), Kengtung (▼US$28/km^2), Matman (▼US$14/$km^2$), and Myitkyina (▼US$6/km^2) will be negatively affected in comparison with the baseline. The relative improvement of the investment climate in the regions along the TLH implies relative deterioration of investment climate in other provinces. Although total impact on Myanmar is positive, uneven distribution of the gains may cause difficulties in implementation. Indeed, this can be a serious bottleneck in Myanmar, where regional disparities already prevailed, and the uneven distribution of the economic impacts can worsen existing ethnic conflicts. In India, several regions in the northeast, particularly those in Assam and Manipur, are expected to gain, although the positive impacts are small. In Thailand, several regions far from the TLH will be affected, namely Samut Prakarn (US$19,091/$km^2$), Samut Sakhon (US$15,661/km^2), Bangkok (US$11,234/$km^2$), and Rayong (US$5,361/km^2), Ayudhya (US$1,964/$km^2$), and Chonburi (US$1,884/km^2), which are existing centres of economic activity.

Figure 6.4. Impact Density of S1 on Subnational Regions



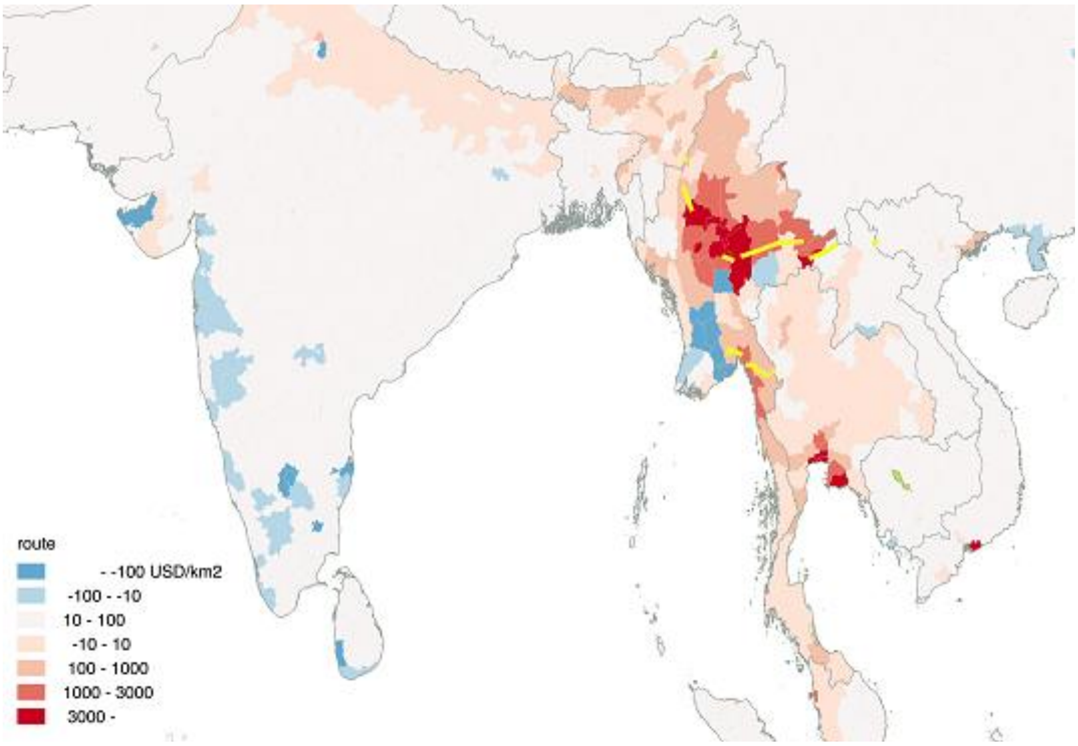
Source: IDE/ERIA–GSM Team.

Figure 6.5. Impact Density of S2a on Subnational Regions



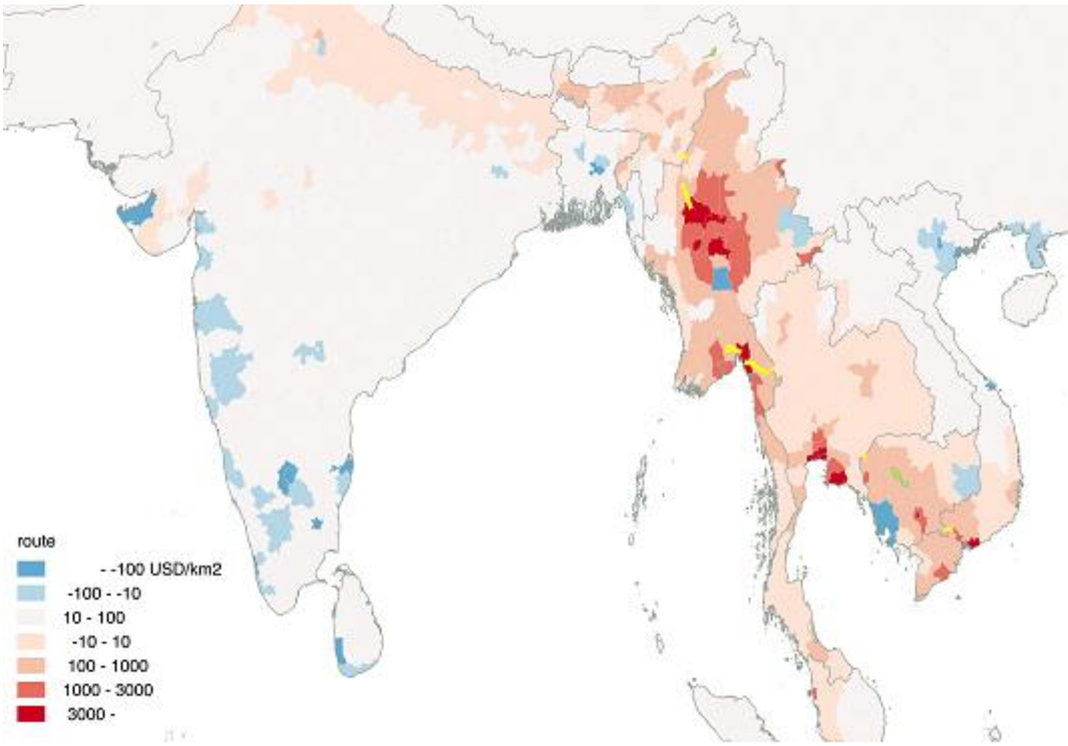
Source: IDE/ERIA–GSM Team.

Figure 6.6. Impact Density of S2b on Sub-National Regions



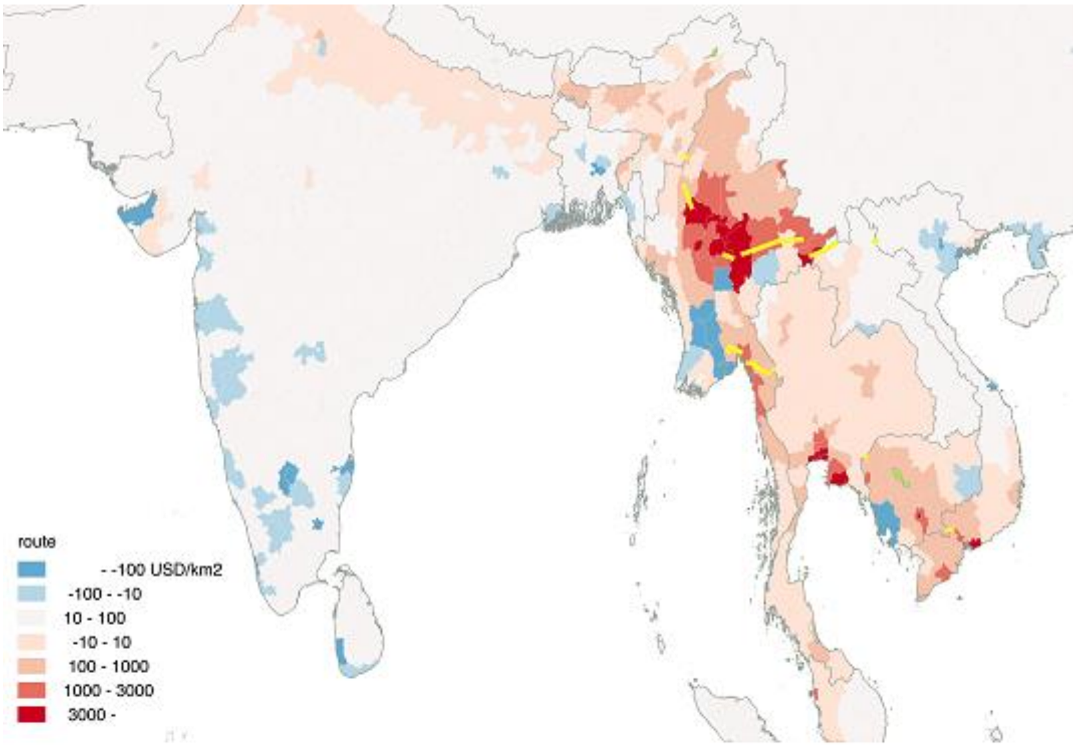
Source: IDE/ERIA–GSM Team.

Figure 6.7. Impact Density of S3 on Sub-National Regions



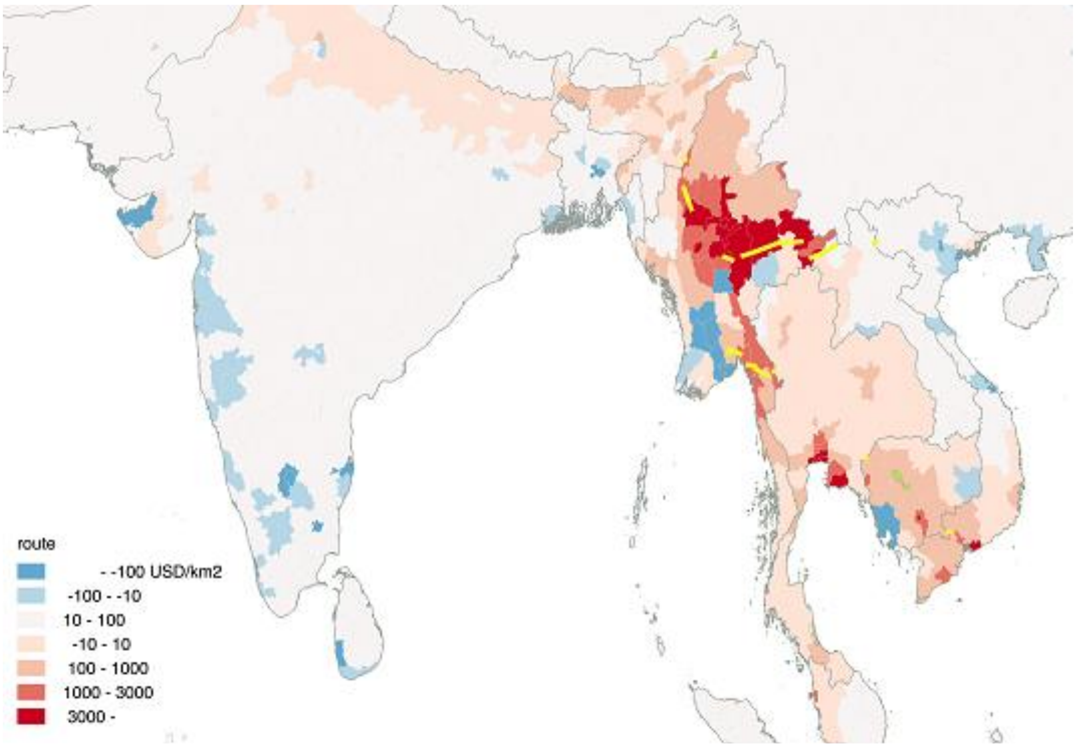
Source: IDE/ERIA–GSM Team.

Figure 6.8. Impact Density of S4a on Subnational Regions



Source: IDE/ERIA–GSM Team.

Figure 6.9. Impact Density of S4b on Subnational Regions



Source: IDE/ERIA–GSM Team.

It is important to highlight that several regions far from the TLH could be affected, such as Ba Ria-Vung Tau (US$3,795/$km^2$) in Viet Nam, Kuala Lumpur (US$5,838/$km^2$) and Pulau Pinang (US$1,556/km^2) in Malaysia, and Singapore (US$2,078/$km^2$).

The northern extension route is expected to affect adjacent regions (Figure 6.6). Mandalay (US$32,506/$km^2$) maintains its position to be the largest beneficiary, followed by Tachileik (US$7,823/$km^2$). Taunggyi (US$5,007/km^2), Kengtung (US$2,457/$km^2$), Loilem (US$2,015/km^2), and Monghpyak (US$1,800/$km^2$) are expected to gain in comparison with the baseline and S1 as well. Comparing the impact densities between S2b and S1, Tachileik is the most significantly affected (+US$7,470/$km^2$), followed by Taunggyi (+US$3,941/$km^2$), Mandalay (+US$3,267/km^2), Kengtung (+US$2,486/$km^2$), and Loilem (+US$2,486/km^2). In contrast, the most significant negative change caused by the northern extension route is in Yangon, where the expected impacts would turn from US$1,097/$km^2$ (S1) to ▼US$574/$km^2$ (S2b). That is, the development of the northern extension route will attract more economic activities to the regions along the road, at the expense of other parts of the country including Yangon.

Northern provinces in Lao PDR and Viet Nam will also be positively affected. In Lao PDR, three provinces along the northern extension route, Oudomxai (US$16/$km^2$), Phongsali (US$10/km^2), and Luang Namtha (US$8/$km^2$), will be positively affected, although the impacts are small. In Viet Nam, in addition to Ba Ria-Vung Tau, Quang Ninh (US$129/$km^2$), Ha Noi (US$94/km^2), and Hai Phong (US$12/$km^2$) will be positively affected in comparison both with the baseline and S1.

The southern extension route (S3) will have more significant impacts on wider provinces in Thailand, Cambodia, and Viet Nam than the northern extension route, probably because it establishes the connection to already better developed road networks (Figure 6.7). In Myanmar, in addition to the regions along the original alignment of the TLH toward India, those toward Thailand will also be positively affected, such as Thaton (US$3,198/$km^2$) and Mawlamyine (US$2,014/km^2). In Cambodia, Phnom Penh, mainly led by textile sector impacts, will be very positively affected (US$203,542/$km^2$) as compared to US$81/km^2 in the case of S1. In Viet Nam, Ba Ria-Vung Tau will experience the largest impact (US$22,023/$km^2$).

The 'all' development scenario (S4a) will of course have the largest and most widespread economic impacts. In Myanmar, large cities along the TLH, including Mandalay (US$32,690/$km^2$), Monywa (US$4,989/km^2), Meiktila (US$4,347/$km^2$), Sagain (US$4,340/km^2), and Kyaukse

(US$3,278/km^2) will be significantly and positively affected. In Cambodia, Phnom Penh (US$203,532/km^2) will gain the most, followed by Kandal (US$2,350/km^2) which surrounds Phnom Penh, Pailin (US$1,809/km^2) near the Thai border, and Svay Rieng (US$690/km^2) facing the border with Viet Nam. In Viet Nam, Ba Ria-Vung Tau (US$21,965/km^2) and Ho Chi Minh City (US$2,620/km^2) will be the two largest beneficiaries. In contrast, metropolitan cities in the north, such as Ha Noi (▼US$973/km^2) and Hai Phong (▼US$209/km^2), will be slightly but negatively affected. Regions along the northern extension route are also positively affected, such as Tachileik (US$12,958/km^2), Taunggyi (US$5,018/km^2), Keng Tung (US$2,458/km^2), and Loilem (US$2,222/km^2) in Myanmar, and Oudomxai (US$17/km^2), Phongsali (US$8/km^2), and Louang Namtha (US$6/km^2) in Lao PDR. These are relatively less-developed regions, even within less-developed countries such as Myanmar and Lao PDR, and have been facing difficulties in economic growth due mainly to the weak connectivity to the other parts of the region. The simulation results of S2b and S4a clearly demonstrate that the northern extension route is an effective way to open these provinces to economic development led mainly by food processing, services, and agriculture.

In Thailand, the biggest positive impacts, which are significantly bigger than those under S1, are expected in Bangkok and surrounding regions. In India, expected impacts of S4a are similar to those of S1, implying that the eastward extension route will not have significant additional impacts over the original alignment of the TLH. In northeastern India, the largest economic impact is expected in Dimapur (US$325/km^2) in Nagaland, followed by Dibrugarh (US$319/km^2), Darrang (US$307/km^2), Sibsagar (US$284/km^2), and Nalbari (US$227/km^2) in Assam, and East Imphal (US$266/km^2), West Imphal (US$241/km^2), Kohima (US$202/km^2), and Thoubal (US$139/km^2) in Manipur.

(4) Impacts on Narrowing the Development Gaps

As discussed above, upgrading road infrastructure and improving border procedures are expected to have positive economic impacts on the regions along the road. While some regions away from the route could suffer from negative impacts (vis-à-vis the baseline), others may have positive impacts, as we observed in Thailand and Viet Nam. That is, the impacts of transport corridors are expected to spread to wider regions differently. In order to investigate distributional consequences of the development of the TLH and its eastward extensions, a variant of the Gini coefficient was computed using the simulation results, which contain the estimates of GRDP and population in each region, and an implicit assumption of perfect equality in each region.

As shown in Table 6.7, the distributional impact of each scenario is very small. Although the impacts of each scenario differ by regions, the distributional impacts are almost invisible because the additional impact generated by each development scenario is expected to be too small.

Table 6.7. Impacts on Gini Coefficients

	# of regions	Base(20)	Base(35)	S1(35)	S2a(35)	S2b(35)	S3(35)	S4a(35)	S4b(35)
India	576	0.447	0.459	0.459	0.459	0.459	0.459	0.459	0.459
Myanmar	69	0.288	0.329	0.331	0.330	0.330	0.331	0.330	0.330
Thailand	76	0.505	0.469	0.468	0.468	0.468	0.468	0.468	0.468
Cambodia	24	0.283	0.306	0.306	0.306	0.306	0.306	0.306	0.306
Lao PDR	17	0.197	0.208	0.208	0.208	0.208	0.208	0.208	0.208
Viet Nam	61	0.448	0.460	0.459	0.459	0.459	0.459	0.459	0.459

Lao PDR = Lao People's Democratic Republic.
Source: Computed based on the simulation results.

6.4. Conclusions

Implications from this simulation analysis can be summarised as follows:

First, the expected impact of the TLH, including its eastward extensions, is not large both in terms of increasing GDP and narrowing development gaps in the region. This is mainly because of the lack of vibrant economic agglomeration along the route. Although Bangkok, Ho Chi Minh City, and Ha Noi are included in the eastward extension routes, they constitute only one side of the original alignment of the TLH. To transform a transport corridor to an economic corridor by stimulating two-way trade, it is important to have at least two economic agglomerations on both sides of the route.[7] The vast potential of Myanmar and the North Eastern Region of India can only be explored through a series of pragmatic policies to remove various bottlenecks.

Second, Myanmar is the largest beneficiary of the TLH and its extension routes, reflecting that most of its original alignment is in its territory. Thailand is the second beneficiary, while the impacts on India are positive but limited in scale. As mentioned above, developing the TLH as a transport corridor is not sufficient to generate bottom-line benefits to Northeast India.

[7] A similar argument can be found in ERIA (2010), claiming that, amongst the three economic corridors in the GMS, the Southern Economic Corridor would generate the largest economic impact because of its having Bangkok and Ho Chi Minh City on both sides of the route.

Third, although the additional impacts caused by the northern and southern extension routes are similar in terms of the total amount, the distributional implication differs substantially. If we compare them only in terms of the expected economic impacts, Myanmar would prefer the northern extension route and others prefer the southern extension route.

Fourth, developing a transport corridor in general will have positive economic impacts on the regions along the route at the expense of other parts of the country or regions. To pursue both economic growth and the narrowing of development gaps, transport corridors need to be designed carefully or with proper redistribution policy measures if necessary. Otherwise, uneven economic impacts may cause unnecessary conflicts in the region or even within a country.

Fifth, the economic impacts will be larger when the degree of improvement in road infrastructure is larger. This implication has two aspects. The lower the quality of the original road, that is, the lower the level of economic development, the larger the potential to enjoy positive economic regional impacts. The large economic impact induced by the northern extension route is probably because it passes through Shan State of Myanmar where economic development is still in an early stage, reflecting weak connectivity to neighbouring countries. The other aspect is drawn from the comparison between S4a and S4b, i.e., that the larger the improvement in the road quality is, the larger the expected economic impacts are. In both cases, the degree of improvement in road infrastructure depends on the size of the investment. The northern extension route will require larger investment because of its inferior condition. In contrast, the southern extension route which aligns with GMS economic corridors, has already been better developed. Similarly, constructing a highway quality road requires bigger investment than constructing a standard road.

Given the relatively fragile security condition in some parts of Myanmar and India, it is important for policymakers to consider distributional consequences of corridor development in addition to usual concerns on total return on investment. As discussed above, the country-wise distribution of the expected economic impact would differ significantly by the choice of the eastward extension routes. In this context, it is very reasonable for Thailand to assist Myanmar to upgrade road infrastructure along the Thai side of the TLH, because it is expected to generate mutual economic benefits. This is also true for India in its assistance to develop the Kalewa–Yargyi section of the TLH.

Regarding the northern extension route, since Myanmar is the only expected beneficiary, it might be difficult to expect bilateral assistance from neighbouring countries, as those donors need to pay close attention to the return on investment. In addition, it might be difficult to expect assistance from ADB, as the route is not designated as a part of the GMS Economic Corridors. It might be possible if the countries concerned shared a common vision to develop a second East–West Economic Corridor for the remaining less-developed regions, namely Shan State of Myanmar, the northern provinces in Lao PDR, and northwestern parts of Viet Nam. In the recent review of the configuration of the GMS economic corridors, ADB (2018a) identifies several subcorridors in the NSEC based on an extensive assessment of the whole system of the GMS Economic Corridors (ADB 2018b-h). Despite its timely and promising progress, the connectivity amongst subcorridors of the NSEC seems to be weak because of the lack of a route, which skews them in an east–west direction. Developing the northern extension route of the TLH as a second East–West Corridor would enhance the NSEC subcorridors by generating synergy from having multiple trade route choices.[8]

[8] In this direction, the relationship between the GMS and India may become a bottleneck.

Appendix to Chapter 6. System of IDE–GSM[9]

A1. Introduction

This technical appendix shows an overview of Geographical Simulation Model developed by the Japan External Trade Organization's Institute of Developing Economies (IDE–GSM). IDE–GSM has several unique features, such as subnational analysis with industrial classifications, multimodal choice, evaluating the economic impact of infrastructure improvements, free-trade agreements (FTAs), and trade facilitation measures. Such a broad scope of analysis comes from its model and data. The model is based on spatial economics, which can capture the concentration of households and firms such as clustering of suppliers and urbanisation, which are essential issues in most of the developing countries, particularly in Asia (Krugman 1991, Fujita et al. 1999). The data include detailed subnational gross regional domestic product (GRDP) by industry in Asia with the rest of the world, and there are more than 3,000 regions over 98 countries/economies, with 71 countries constituting the rest of the world. All the regions and countries are on the transport networks by road, railway, ship, and air, if they exist. With such data, IDE–GSM enables evaluating regional connectivity in improved physical infrastructure, such as new roads and bridges for missing links, and upgrading of existing roads, and in non-physical infrastructure such as trade facilitation measures, harmonisation of custom procedures, and reductions in administrative procedures for trades.

The main objective of IDE–GSM is to analyse regional dynamics in population and economic growth with and without specific infrastructure projects. IDE–GSM can prioritise various infrastructure development projects and offer an objective evaluation tool for policy recommendation in infrastructure development.

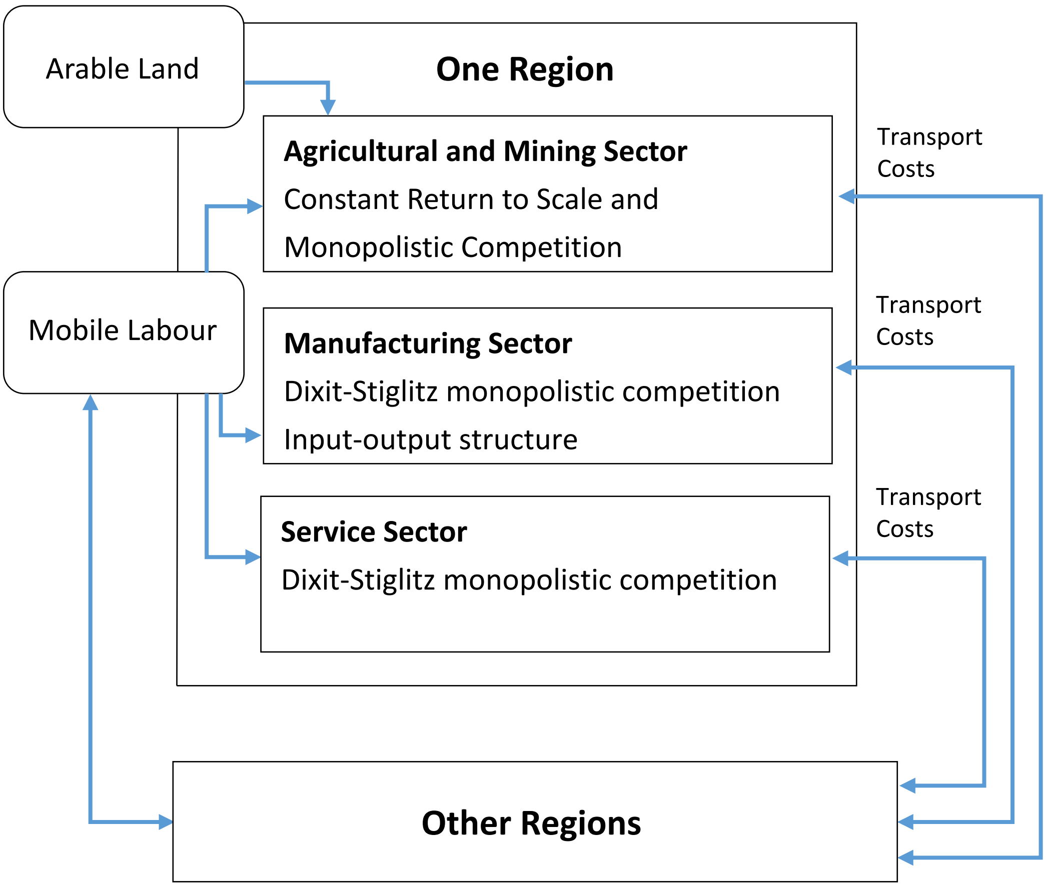
The analysis typically shows the difference between deploying and forgoing projects; in other words, with scenarios and benchmark case. This makes it easy to compare the scenarios, namely, development projects, with the aggregate showing the best possible combination.

[9] This technical appendix was prepared by Mr. Satoru Kumagai of IDE–JETRO, the principle developer of the IDE/ERIA–GSM, in order to facilitate the understanding of the simulation results presented in Chapter 6.

A2. The model[10]

Our model is multiregional and multisectoral.[11] It features agriculture and mining, five manufacturing sectors, and the service sector. Our model accommodates worker mobility within countries and between sectors.

Figure A1. Basic Structure of the Model in the Simulation



Source: Authors.

[10] It is a modified version of Kumagai and Isono (2011).

[11] For other simulation analysis based on New Economic Geography, see Teixeira (2006) and Robert et al. (2012).

The theoretical foundation follows Puga and Venables (1996), which captures the New Economic Geography's multisector and country general equilibrium. Therefore, the explanation below mainly pertains to equations in equilibrium. However, it is noteworthy that our model differs from that in Puga and Venables (1996) in specifications of the agricultural sector, which explicitly incorporate land size in its production and keep its technology as constant returns to scale.[12]

All products in the three sectors are tradable. The transport cost is assumed to be an iceberg type. That is, if one unit of a good is sent from one area to another, a good with less than one portion arrives. Depending on the loss, the supplier sets a higher price. The increase in price compared to that of the producer place is considered as the transport cost. Transport costs within the same area are considered negligible.

This simulation model determines the following regional variables: nominal wage rates in three sectors; land rent; regional income; regional expenditure on manufactured goods, the price index of three sectors; average real wage rates in three sectors; population share of a location in a country; and population shares of a sector in three industries within one location.

The agricultural and mining sector assume monopolistic competition with constant returns to scale technology and Armington's assumptions. The manufacturing and service industries use a Dixit–Stiglitz-type monopolistic competition and increase returns to scale technology. While an input–output linkage is assumed in the manufacturing industry, no linkage is assumed in the service industry.

Regional incomes in the New Economic Geography model correspond to regional GDPs in our simulations. Assuming that revenues from land at location *r* belong to households at location *r*, GDP at location *r* is expressed as follows:

$$Y_i = \sum_{J\in\{5\text{ manufacturing industries,services}\}} w_{Ji}L_{Ji} + \sum_{H\in\{\text{agriculture, mining}\}} p_{Hi}f_{Hi} + TA_i$$

where w_{Ji} is the nominal wage rates in manufacturing and the services sector at location *i*, and L_{Ji} is the labour input of manufacturing and the services sector at location *i*, p_{Hi} is the price

[12] For detailed derivations, see Puga and Venables (1996) and Fujita et al. (1999).

of an agricultural/mining product at location *i*, $f_{Hi}$is agricultural/mining products at location *i*, respectively. TA_i is the redistributed tariff revenue at location *i*.

The price indices of agricultural/mining goods, manufactured goods, and services products at location *i* are expressed as follows:

$$G_{H,i}^{-(\sigma_A-1)} = \sum_{j=1}^{R}\left[A_{Hj}^{-1}\alpha_H^{-1}\left(\frac{F_{Hj}}{L_{Aj}}\right)^{-(1-\alpha_H)} w_{Hj}T_H(j,i)\right]^{-(\sigma_H-1)}$$

$$G_{ki}^{-(\sigma_k-1)} = \left(\frac{\sigma_k-1}{\sigma_k}\right)^{\sigma_k}\sum_{j=1}^{R} L_{kj}\,A_{kj}^{\sigma_k}w_{kj}^{1-\sigma_k(\alpha_k)}G_{kj}^{-(1-\alpha_k)\sigma_k}T_k(j,i)^{-(\sigma_k-1)}, and$$

$$G_{Si}^{-(\sigma_S-1)} = \left(\frac{\sigma_S}{\sigma_S-1}\right)^{-(\sigma_S-1)}\frac{1}{\mu_S}\sum_{j=1}^{R} L_{Sj}\left(A_{Sj}\right)^{\sigma_S}\left(w_{Sj}\right)^{-(\sigma_S-1)}T_S(j,i)^{-(\sigma_S-1)}.$$

Where F_{Hi} is the land used for the production at location *i*, α_I is the labour input share for production, μ_I is the consumption share of products, A_{Ii} is productivity parameter for location *i*, $T_I(j,i)$ stands for the iceberg transport costs from location *j* to location *i*, and $\sigma_I$is the elasticity of substitution between any two differentiated manufactured goods for agricultural, manufactured and services goods, respectively. Nominal wages in the agricultural, manufacturing, and services sectors at location *i* are expressed as follows:

$$w_{Hi} = A_{Hi}\alpha_H\left(\frac{F_{Hi}}{L_{Hi}}\right)^{1-\alpha_H} p_{Hi},$$

$$w_{ki} = \left\{\frac{\sigma_k-1}{\sigma_k}A_{ki}\left[\alpha_k\sum_{j=1}^{R}E_{kj}\,G_{kj}^{\sigma_k-1}T_k(i,j)^{1-\sigma_k}\right]^{1/\sigma_k}G_{ki}^{-\beta}\right\}^{1/(1-\beta)}, and$$

$$w_{Si} = \left(\frac{\sigma_S - 1}{\sigma_S}\right)^{1-1/\sigma_S} A_{Si} \left[\sum_{j=1}^{R} Y_j\, G_{Sj}^{\sigma_S - 1} T_S(i,j)^{1-\sigma_S}\right]^{1/\sigma_S}.$$

The variables are decided using a given configuration of labour. Derived gross regional domestic product (GRDP), nominal wage rates, and price indexes are used to determine labour's decision on a working sector and place. The dynamics for labour to decide on a specific sector within a location are expressed as follows:

$$\dot{\lambda}_{I,i} = \gamma_I \left(\frac{\omega_{Ii}}{\omega_i} - 1\right) \lambda_{I,i}, I \in \{\text{the list of all industries}\}$$

where $\dot{\lambda}_{I,i}$ is the change in labour (population) share for a sector within a location, γ_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 *r*, ω_i is the average real wage rate at location *i*, and $\lambda_{I,i}$ is the labour share for a sector in the location.

The dynamics of labour migration between regions is expressed as follows:

$$\dot{\lambda}_i = \gamma_L \left(\frac{\omega_i}{\overline{\omega}_C} - 1\right) \lambda_i$$

where $\dot{\lambda}_i$ is the change in the labour share of a location in a country, γ_L is the parameter for determining the speed of migration between locations, λ_i is the population share of a location in a country, and $\overline{\omega}_C$ shows the average real wage rate of the country. ω_i shows the real wage rate of a location and is specified as follows:

$$\omega_i = \frac{Y_i / \sum_{I \in \{the\ list\ of\ all\ industries\}} L_{Ii}}{\prod_{I \in \{the\ list\ of all\ industries\}} G_{Ii}^{\mu_I}}.$$

where μ_I shows the consumption share of each industry.

A3. Data

Data for IDE/GSM cover 98 countries/economies divided into 3,065 regions and we utilise country data for 71 rest-of-the-world countries/economies. In total, we have 3,136 regions in the model. Primarily based on official statistics, we derive GRDP for the agricultural sector and mining sector, five manufacturing sectors, and the service sector for 2010. The five manufacturing sectors are automotive (Auto), electronics and electric appliances (E&E), garment and textile (Textile), food processing (FoodProc) and other manufacturing (OtherMfg). Population and area of arable land for each region are compiled from multiple statistical sources. The administrative unit adopted in the simulation is one level or two levels below the national level. For instance, the administrative unit is one level below the national level for Cambodia, Japan, Republic of Korea, Lao PDR, Malaysia, the Philippines, Taiwan, Thailand, and Viet Nam. For Bangladesh, China, India, Indonesia, and Myanmar, the administrative unit is two levels below the national level. Brunei Darussalam, Hong Kong, Macao, and Singapore are treated as one unit. For the US, the administrative unit is state level, while for the European Union, the administrative unit is Nomenclature of Units for Territorial Statistics (NUTS)-2 level in this version of IDE–GSM.

A4. Parameters

Our transport cost comprises physical transport costs, time costs, tariff rates, and non-tariff barriers (TNTBs). Physical transport costs are a function of distance travelled, travel speed per hour, physical travel cost per km, and holding cost for domestic/international transshipment at border crossings, stations, ports, or airports. 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. Travel speed per hour is provided in the next section. These parameters are derived from JETRO's 2008 ASEAN Logistics Network Map, and by estimating the model of the firm-level transport mode choice with the 'Establishment Survey on Innovation and Production Network'[13] for 2008 and 2009, which includes manufacturers in Indonesia, the Philippines, Thailand, and Viet Nam. Based on these parameters, we calculate the sum of physical transport and time costs for all possible routes between the two regions. Employing the

[13] This survey was conducted by ERIA.

Floyd–Warshall algorithm for determining the optimal route and transport mode for each region and good, we obtain the sum of physical transport and time costs for each pairing of two regions by industry (Cormen et al., 2001).

We assume that firms choose a transportation mode from amongst air, sea, and truck:

$$V_M \equiv U_M + \varepsilon_M = \alpha \cdot Abroad_{ji} + \sum_s \beta_s^M u_s \ln d_{ji} + \sum_k \gamma_k^M v_k + \varepsilon_M ,$$

where ε_M denotes unobservable mode characteristics, while $Abroad_{ji}$ takes unity if regions i and j belong to different countries and zero otherwise; d_{ji} is the geographical distance between regions i and j. u_s is industry dummy. When ε_M is independent and follows the identical type I extreme value distribution across modes, the probability that the firm chooses mode M is given by:

$$\Pr\left(Y_i = M \mid Abroad_{ji}, \ln d_{ji}\right) = \frac{e^{U_M}}{1 + e^{U_{Air}} + e^{U_{Truck}} + e^{U_{Sea}}}$$

for M = Air, Sea, Truck. (1)

The coefficients are estimated by maximum likelihood procedures. In other words, a multinomial logit (MNL) model is used to estimate the probability that a firm chooses one of the three transportation modes: air, sea, and truck. In the following, the truck is a base mode.

The geographical distance affects firms' modal choices through not only a per-unit physical charge for shipments but also shipping time costs due to the nature of the demand for shipments. Transportation time has a larger influence on the price of products that decay rapidly over time; for example, time-sensitive products include perishable goods (fresh vegetables), new information goods (newspapers) and specialised intermediate inputs (parts for Just-In-Time production). Lengthy shipping time may lead to a complete loss of commercial opportunity for products and their components, which is more likely to be significant for goods with a rapid product life cycle and high demand volatility. Given the value of timeliness in selling a product, time costs are small for timely shipments (short transport time). In other words, time costs will be the highest for shipping by sea and the lowest for shipping by air. On the other hand, the physical transport costs will be highest for air and the lowest for the sea. Truck transport will have a medium level of costs compared to air and sea transport. As a result, the coefficient for the geographical distance represents the average difference in the sum of the above two kinds of transport costs (time and physical transportation) per distance between truck and air/sea.

Furthermore, three points are noteworthy. Firstly, as mentioned above, shipping time costs obviously differ amongst industries. Such differences are controlled by introducing the intercepts of industry dummy variables (u_s) with distance variables. Secondly, the level of port infrastructure is obviously different amongst countries. This yields different impacts of the aforementioned two kinds of transport costs. To control such differences amongst countries in which reporting firms locate, we introduce country dummy variables (v_k). Lastly, qualitative differences between intra- and international transactions are controlled by introducing a binary variable (*Abroad*), taking unity if transactions are international and zero if otherwise.

Our main data source is the Establishment Survey on Innovation and Production Network for selected manufacturing firms in four countries in East Asia for 2008 and 2009 (Table 1). The four countries covered in the survey were Indonesia, the Philippines, Thailand and Viet Nam. The sample population is restricted to selected manufacturing hubs in each country (JABODETABEK area, i.e., Jakarta, Bogor, Depok, Tangerang, and Bekasi, for Indonesia; CALABARZON area, i.e., Cavite, Laguna, Batangas, Rizal, and Quezon, for the Philippines; Greater Bangkok area for Thailand; and Ha Noi area and Ho Chi Minh City for Viet Nam). This dataset includes information on the mode of transport that each firm chooses in supplying its main product and sourcing its main intermediate inputs. From there, the products' origin and destination can also be identified. In our analysis, however, the combination of origin and destination is restricted to one accessible by land transportation.

Table A1. The Combination of Trading Partners in the Dataset

	Indonesia	Philippines	Thailand	Viet Nam
Cambodia				1
China			6	52
Hong Kong				5
Indonesia	449			
Malaysia				2
Myanmar			1	
Philippines		254		
Singapore				2
Thailand			151	7
Viet Nam				382

Source: The Establishment Survey on Innovation and Production Network.

Let us take a brief look at a firms' choice of transportation mode. Table 1 reports the combination of trading partners in our dataset. There are three noteworthy points here. Firstly, as mentioned above, firms in the Philippines and Indonesia are restricted to the ones with intra-national transactions, although most of the firms in the other countries in our dataset are also engaged in intra-national transactions. Secondly, there are a relatively large number of Vietnamese firms trading with China. Third, Table 2 shows the transportation mode by the location of firms, indicating that most of our sample firms tend to choose trucks. Intuitively, this may be consistent with the first fact that most of the firms trade domestically.

Table A2. The Chosen Transportation Mode by Location of Firms

	Indonesia	Philippines	Thailand	Viet Nam
Air	19	7	2	11
Sea	17	11	6	51
Truck	413	236	150	389

Source: The Establishment Survey on Innovation and Production Network.

The MNL result is provided in Table 3. There are three noteworthy points. Firstly, in trading with partners abroad, firms are likely to choose air or sea. Secondly, the coefficients for distance are estimated to be significantly positive, indicating that the larger the distance between trading partners, the more likely the firms are to choose air or sea. Specifically, this result implies that the two kinds of transport costs per distance are lower in air and sea than by truck. Thirdly, the intercept term of distance in machinery industries has a significantly positive coefficient for air. This result may indicate a large amount of time costs in the machinery industry.

Table A3. Result of Multinomial Logit Analysis

Truck as a basis	Air			Sea		
	Coef.		S.D.	Coef.		S.D.
Abroad	3.573	***	0.736	2.915	***	0.428
ln Distance (Food as a basis)	0.444	***	0.170	1.268	***	0.167
*Textiles	0.104		0.126	-0.151		0.094
*Machineries	0.300	**	0.135	0.112		0.086
*Automobile	0.201		0.174	-0.104		0.154
*Others	0.148		0.106	-0.068		0.066
Constant	-5.711	***	0.760	-9.621	***	0.993
Country dummy: Indonesia as a basis						
Philippines	-0.336		0.470	0.364		0.446
Thailand	-2.239	**	0.904	-0.794		0.624
Viet Nam	-2.483	***	0.683	-0.437		0.419
Statistics						
Observations			1,312			
Pseudo R-squared			0.3407			
Log-likelihood			-321.5			

*Note:****, **, and * show 1%, 5%, and 10% significance, respectively.
Source: Authors' calculation.

Lastly, we conduct some simulations to get a more intuitive picture of the transportation modal choice. Specifically, employing our estimators, we calculate the distance between trading partners in which the two transportation modes become indifferent in terms of their probability. For example, suppose that a firm in the food industry in Bangkok trades with a partner located in another city. Our calculation reveals how far the city is from Bangkok if the probability of choosing air/sea is equal to that of choosing truck transport. In the calculation, we set *Abroad* to the value of 1, i.e., international transactions. The results are reported in Table 4. In Bangkok, for example, firms in the machinery industry choose air or sea if their trading partners are located more than 400 km away. On the other hand, firms in the food industry basically only use the truck.

Table A4. Probability Equivalent Distance with Truck (km): Domestic and International Transportation from Bangkok

	Domestic		International	
	Air	**Sea**	**Air**	**Sea**
Food	60,300,000	3,699	19,254	371
Textiles	2,022,900	11,218	2,968	825
Machineries	44,009	1,899	361	229
Automobile	225,394	7,693	886	628
Others	684,540	5,909	1,634	520

Source: Authors' calculation based on the MNL result in Table 3.

We estimate some parameters necessary for calculating transport costs. Specifically, we estimate transportation speed and holding time. Our strategy for estimating those is very straightforward and simple. We regress the following equation:

$$Time_{ij}^{M} = \rho_0 + \rho_1 Abroad_{ij}^{M} + \rho_2 Distance_{ij}^{M} + \varepsilon_{ij}^{M}.$$

The coefficients $\rho_0^M$and ρ_1^M represent mode M's holding time in domestic transportation and its additional time in international transportation, respectively. The inverse of ρ_2^M indicates the average transportation speed in mode M. We use the same data as in the previous section. However, the estimation in this section does not require us to restrict our sample to firms with transactions between regions accessible by truck.

The OLS regression results are reported in Table 5. Although some of the holding time coefficients, i.e., ρ_0^M and ρ_1^M, are estimated as being insignificant, their magnitude is reasonable enough. As for the distance coefficient, its magnitude in sea and truck is reasonable, but that in the air is disappointing and too far from the intuitive speed, say, around 800 km/h. One possible reason is that ‘time’ in our dataset always includes land transportation time to the airport. This will cause the air transportation speed to be understated.

Table A5. Results of OLS Regression: Holding Time and Transportation Speed

	Air	Sea	Truck
Estimation Results			
Abroad	9.010	11.671	10.979***
	[8.350]	[13.320]	[2.440]
Distance	0.018*	0.068***	0.026***
	[0.010]	[0.018]	[0.002]
Constant	6.123	3.301	2.245***
	[7.940]	[13.099]	[0.739]
Holding Time (hours)			
Domestic	9.010	11.671	10.979
International	15.133	14.972	13.224
Speed (km/hour)	55.556	14.706	38.462
Observations	51	34	754
R-squared	0.1225	0.3698	0.1772

OLS = ordinary least squares.
Notes: ***, **, and * show 1%, 5%, and 10% significance, respectively. A dependent variable is transportation time.
Source: Authors’ calculation.

We specify a simple linear transport cost function, which consists of physical transport costs and time costs. We assume the behaviour of the representative firm for each industry as follows:

- A representative firm in the machinery industry will make a choice between the truck and air transport and choose the mode with a higher probability in (1).
- A representative firm in the other industries will choose between truck and sea transport and choose the mode with the higher probability in (1).

Specifically, the transport cost in the industry *s* by mode *M* between regions *i* and *j* is assumed to be expressed as:

$$C_{ij}^{s,M} = \underbrace{\left[\left(\frac{dist_{ij}}{Speed_M}\right) + \left(1 - Abroad_{ij}\right) \times ttrans_M^{Dom} + Abroad_{ij} \times ttrans_M^{Intl}\right]}_{Total\ \ Transport\ \ Time} \times ctime_s$$

$$+ \underbrace{dist_{ij} \times cdist_M}_{Physical\ \ Transport\ \ Cost} + \underbrace{\left(1 - Abroad_{ij}\right) \times ctrans_M^{Dom} + Abroad_{ij} \times ctrans_M^{Intl}}_{Physical\ \ Transshipment\ \ Cost} \qquad (2)$$

where $dist_{ij}$ is the travel distance between regions i and j, $speed_M$ is travel speed per one hour by mode M, $cdist_M$ is physical travel cost per 1 km by mode M, and $ctime_s$ is time cost per one hour perceived by firms in industry s. The parameters $ttrans_M^{Dom}$ and $ctrans_M^{Dom}$ are the holding time and cost, respectively, for domestic transshipment at ports or airports. Similarly, $ttrans_M^{Intl}$ and $ctrans_M^{Intl}$ are the holding time and cost, respectively, for international transshipment at borders, ports, or airports.

The parameters in the transport function are determined as follows. Firstly, by using the parameters obtained from the results of estimation and borrowing some parameters from JETRO (2008), we set some of the parameters in the transport function as in Table 6. Notice that our estimates of $Speed_{\mathrm{Air}}$ and $ttrans_{\mathrm{Air}}^{Intl}$ in Table 6 went beyond our expectations. Thus, we set $Speed_{\mathrm{Air}}$ at the usual level (800 km/h) and we made $ttrans_{\mathrm{Air}}^{Intl}$ consistent with JETRO (2008).

Secondly, after substituting those parameters for the equation (2) under domestic transportation, $C_{ij}^{s,M}$ becomes a function of $dist_{ij}$ and $ctime_s$. To meet the above-mentioned assumptions on firms' behaviour, we add the following conditions:

Table A6. Parameters in the Transport Cost Function

	Truck	Sea	Air	Unit	Source
$cdist_M$	1	0.24	45.2	US$/km	Map
$Speed_M$	38.5	14.7	800	km/hour	Table A5
$ttrans_M^{Dom}$	0	11.671	9.01	hours	Table A5
$ttrans_M^{Intl}$	13.224	14.972	12.813	hours	Table A5 & Map
$ctrans_M^{Dom}$	0	190	690	US$	Map
$ctrans_M^{Intl}$	500	N.A.	N.A.	US$	Map

Notes: Costs are for a 20-foot container. The parameter $ctrans_M^{Dom}$ is assumed to be half of the sum of border costs and transshipment costs in international transport from Bangkok to Ha Noi. The parameter s$ttrans_M^{Dom}$ and $ctrans_M^{Dom}$ for sea and air include one-time loading at the origin and one-time unloading at the destination.
Source: Authors' estimation and JETRO (2008).

- The transport cost using trucks becomes the lowest amongst the three modes when $dist_{ij}$ is zero for each industry.
- If the transport cost is depicted as a function of $dist_{ij}$, a line is drawn by the function where truck intersects with it at only one point for air and sea for the machinery industry, and at only one point for the other industries with all non-negative $dist_{ij}$.

Under the probability equivalent (domestic) distances in Table 4, the transport cost $C^{s,Air}$ should be equal to $C^{s,Truck}$ in machineries, and $C^{s,Sea}$ should be equal to $C^{s,Truck}$ in the other industries. By using this equality, we calculate $ctime_s$ for each industry as in Table A7. The functions meet the above conditions.

Table A7. Time Costs per One Hour by Industry perceived by Firms (*ctimes*): US$/hour

	Food	Textile	Machineries	Automobile	Others
$ctime_s$	15.7	17.2	1,803.3	16.9	16.5

Source: Authors' calculation.

Thirdly, by substituting these parameters again, including $ctime_s$ and $ctrans_{\mathrm{Truck}}^{Intl}$ under international transportation, $C_{ij}^{s,Truck}$ becomes a function of only $dist_{ij}$, and $C_{ij}^{s,M}$ for air and sea becomes a function of $dist_{ij}$ and $ctrans_{\mathrm{M}}^{Intl}$. Then by using the probability equivalent (international) distances in Table A4 again, we can calculate $ctrans_{\mathrm{Air}}^{Intl}$ and $ctrans_{\mathrm{Sea}}^{Intl}$ for each industry. Lastly, $ctrans_{\mathrm{Sea}}^{Intl}$ is uniquely set as the average amongst the other industries. These parameter values are reported in Table A8. The functions obtained also fulfil the above conditions.

Table A8. Costs for Transshipment in International Transport ($ctrans_M^{Intl}$): US$

	Truck	Sea	Air
$ctrans_M^{Intl}$	500	504.2	1,380.1

Source: Authors' calculation.

Additionally, $ttrans^{Dom}$ and speed of railway are estimated by the same dataset and the same estimating equation. Due to the minimal usage of railways in international transactions in the dataset, we adopted the same value for the time and cost of international transactions as in trucks from Table A9. Finally, we set the cost per km as half the value of road transport.[14]

Table A9. Parameters for Rail Transport

	Railway	Unit	Source
$cdist_M$	0.5	US$/km	Half of Truck
$Speed_M$	19.1	km/hour	Estimation
$ttrans_M^{Dom}$	2.733	hours	Estimation
$ttrans_M^{Intl}$	13.224	hours	Same as Truck
$ctrans_M^{Intl}$	500	US$	Same as Truck

Source: Authors' calculation.

The sum of tariff and TNTBs by countries is estimated by employing the 'log odds ratio approach', which is initiated by Head and Mayer (2000). Namely, we estimate the industry-level border barriers for each country (not each subnational region). This approach looks more appropriate than other approaches because the theoretical model underlying it is basically the same as our GSM. We estimate for the ratio of 'consumption of products from country j in country i (X_{ij})' to 'consumption of products from country i in country i (X_{ii})'. For brevity, we omit an industry subscript. Specifically, such a ratio is given by the following:

$$\frac{X_{ij}}{X_{ii}} = \left(\frac{n_j}{n_i}\right)\left(\frac{a_{ii}}{a_{ij}}\right)^{1-\sigma}\left(\frac{t_{ij}}{t_{ii}}\right)^{1-\sigma}\left(\frac{p_j}{p_i}\right)^{1-\sigma}$$

n, a, t, σ, and p represent the mass of varieties, a parameter on preference weight, transport costs, the elasticity of substitution across varieties, and product prices, respectively.

[14] JETRO (2008) offers an example where the cost per km for railways is 0.85 times that of trucks. However, it is only for the case when we ship a quantity that can be loaded onto a truck. Rail has much larger economies of scale than trucks in terms of shipping volume so some industries such as coal haulage incur much lower cost per tonne km. Therefore, we need to deduct this from the value in JETRO (2008).

To estimate this model with the available data, we assume the following. First, the mass of varieties is assumed to be related to the size of GDP. Second, we assume that the ratio of preference parameters is explained by linguistic commonality (*Language*), colonial relationship (*Colony*), and geographical contiguity (*Contiguity*). These variables are expressed as binary variables. Third, the transport costs are assumed to be expressed as the following.

$$\ln\left(\frac{t_{ij}}{t_{ii}}\right) = Border_i + \alpha \ln\left(\frac{Distance_{ij}}{Distance_{ii}}\right) + \beta \ln Cost_{ij}$$

$Border_{ij}$ shows the TNTB while $Distance_{ij}$ is the geographical distance between countries *i* and *j*. The domestic distance, i.e., $Distance_{ii}$, is computed as the following:

$$Distance_{ii} = \frac{2}{3}\sqrt{\frac{Area_i}{\pi}}$$

π and *Area* are circular constant and surface area, respectively. *Cost* is the sum of physical transport costs and time costs, of which computation is explained before. Last, product prices are assumed to be a function of wages, for which GDP per capita is used as a proxy.

Under these assumptions, the above equation can be rewritten as follows.

$$\ln\left(\frac{X_{ij}}{X_{ii}}\right) = \gamma_1 \ln\left(\frac{GDP_j}{GDP_i}\right) + \gamma_2 Language_{ij} + \gamma_1 Colony_{ij} + \gamma_3 Contiguity_{ij}$$
$$+ \gamma_4 \ln\left(\frac{Distance_{ij}}{Distance_{ii}}\right) + \gamma_5 \ln Cost_{ij} + \gamma_6 \ln\left(\frac{GDP\ per\ capita_j}{GDP\ per\ capita_i}\right) + u_i + \epsilon_{ij}$$

u_i shows fixed effects for country *i* and, from the theoretical point of view, the log value of the product between *Border* and (1−σ). Therefore, we compute the TNTB by employing the estimates for these fixed effects and the elasticity of substitution. The estimation is conducted for agriculture, manufacturing, and services separately. In the case of manufacturing, we estimate the model by pooling the data for five sectors under controlling for sector fixed effects.

We estimate the above model for the year 2007. The data sources are as follows. The consumption data are obtained from the GTAP 8 Data Base. The data on GDP and GDP per capita are obtained from the World Development Indicator (World Bank). Those on geographical distance and three dummy variables on preferences are from CEPII database. With this methodology, we estimate industry-level fixed effects for 69 countries.

The estimation results by the ordinary least square (OLS) method are reported in Table 10. Almost all variables have significant coefficients with expected signs though the coefficients for GDP per capita ratio are positively significant in manufacturing and services. This estimation provides us the estimates on industry-level fixed effects for 69 countries. In order to obtain those in the other countries, we assume that those in each country are highly correlated with their GDP per capita and regress (log of) GDP per capita, in addition to industry dummy variables on the estimates of these fixed effects. The estimation results are the following.

$$\begin{aligned}\text{Estimates on Fixed Effects} = {} & -17.797 + 1.245 * \ln \text{GDP per capita} + 1.365 * \text{Food} \\ & + 2.555 * \text{Textile} + 2.052 * \text{Electric Machinery} + 1.569 * \text{Automobile} \\ & + 2.523 * \text{Other Manufacturing} - 1.149 * \text{Services}\end{aligned}$$

The number of observations is 483, and the adjusted R-squared is 0.7386. The base for industry dummy variables is agriculture. Using the estimation results and the data on GDP per capita, we predict industry-level fixed effects for other 126 countries. As a result, we obtain those for 195 countries in total. Applying the elasticity of substitution to these estimates, we compute the tariff equivalent of TNTB.

Table A10. OLS Results

	Agriculture	Manufacturing	Services
GDP ratio	0.968***	1.346***	0.677***
	(0.020)	(0.011)	(0.008)
Language	1.115***	0.684***	0.146***
	(0.126)	(0.070)	(0.048)
Colony	0.508**	0.173	0.268***
	(0.204)	(0.114)	(0.078)
Contiguity	1.821***	1.090***	0.464***
	(0.186)	(0.103)	(0.071)
Distance ratio	-0.555***	-1.000***	-0.016
	(0.086)	(0.036)	(0.038)
Cost	-0.743***	-0.576***	-0.459***
	(0.194)	(0.206)	(0.068)
GDP per capita ratio	-0.593***	0.134***	0.301***
	(0.024)	(0.013)	(0.009)
Sector Dummy (Base: Automobile)			
Food		-0.207***	
		(0.064)	
Textile		1.016***	
		(0.070)	
Electric Machinery		0.491***	
		(0.053)	
Other Manufacturing		0.981***	
		(0.053)	
Number of Observations	4,592	23,460	4,692
Adjusted R-squared	0.6076	0.6192	0.8508

GDP = gross domestic product, OLS = ordinary least squares.

Notes: *** and ** indicate 1% and 5% significance, respectively. In the parenthesis is the robust standard error. All specifications include import country dummy variables.

Source: Authors' calculation.

Next, we obtain NTBs by subtracting tariff rates from TNTB. Our data source for tariff rates is the World Integrated Trade Solution, particularly Trade Analysis and Information System raw data. For each trading pair, we aggregate the lowest tariff rates amongst all available tariff schemes at the tariff-line level into single tariff rates for each industry by taking a simple average. Available tariff schemes include multilateral FTAs (e.g., ASEAN+1 FTAs) and bilateral FTAs (e.g., China–Singapore FTA) alongside other schemes such as the Generalised System of Preferences. Moreover, we somewhat consider the gradual tariff elimination schedule in six ASEAN + 1 FTAs in addition to the ASEAN free trade area (AFTA). For example, in the case of ASEAN–Japan Comprehensive Economic Partnership (AJCEP), tariff rates amongst member countries began to gradually decline from 2008. Tariff rates in Japan and ASEAN forerunners against members are for simplicity assumed to linearly decrease to become final rates in 2018, and those for ASEAN latecomers decrease linearly to final rates in 2026.[15] 'Final rates' takes into account the final rates set in each agreement. Namely, even if tariff rates for a product were not zero in 2009, they are set to zero in 2026 if they involve preferential products. We obtain information about whether each product finally attains zero rates in ASEAN + 1 FTAs from the FTA database developed in ERIA. We set final rates for all products in the case of AFTA at zero due to the lack of such information. As a result, we obtain separately (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.

Another important setting on transport cost is the 'cumulation rule' in multilateral FTAs, particularly ASEAN+1 FTAs and AFTA. There are several types of cumulation rules: bilateral, diagonal, and full. Some scholarly studies try to quantify the trade creation effect of diagonal cumulation. Particularly in Hayakawa (2014), which examines Thai exports to Japan, the tariff equivalent of the diagonal cumulation rule in the ASEAN–Japan Comprehensive Economic Partnership is estimated at around 3%. Based on this estimate, we formalise the effect of the diagonal cumulation rule amongst ASEAN + 1 FTAs as 3% below NTBs in trading amongst members after each FTA's entry into force.

We adopt the elasticity of substitution for each sector mainly from Hummels (1999) and estimate it for services, as 3.8 for Agriculture, 5.1 for FoodProc, 8.4 for Textile, 6.0 for E&E, 4.0 for Auto, 5.3 for OtherMfg, and 3.0 for services. Estimates for the elasticity of services are obtained from the estimation of the usual gravity equation for services trade, including as independent variables importer's GDP, exporter's GDP, importer's corporate tax, geographical distance

[15] We do not insert the exact schedule of gradual tariff reductions due to the lack of ready-made information.

between countries, a dummy for free trade agreements, a linguistic commonality dummy, and the colonial dummy. The elasticity for services is obtained from the transformation of a coefficient for the corporate tax because it changes prices of services directly. For this estimation, we mainly employ data from 'Organisation for Economic Co-operation and Development Statistics on International Trade in Services.'

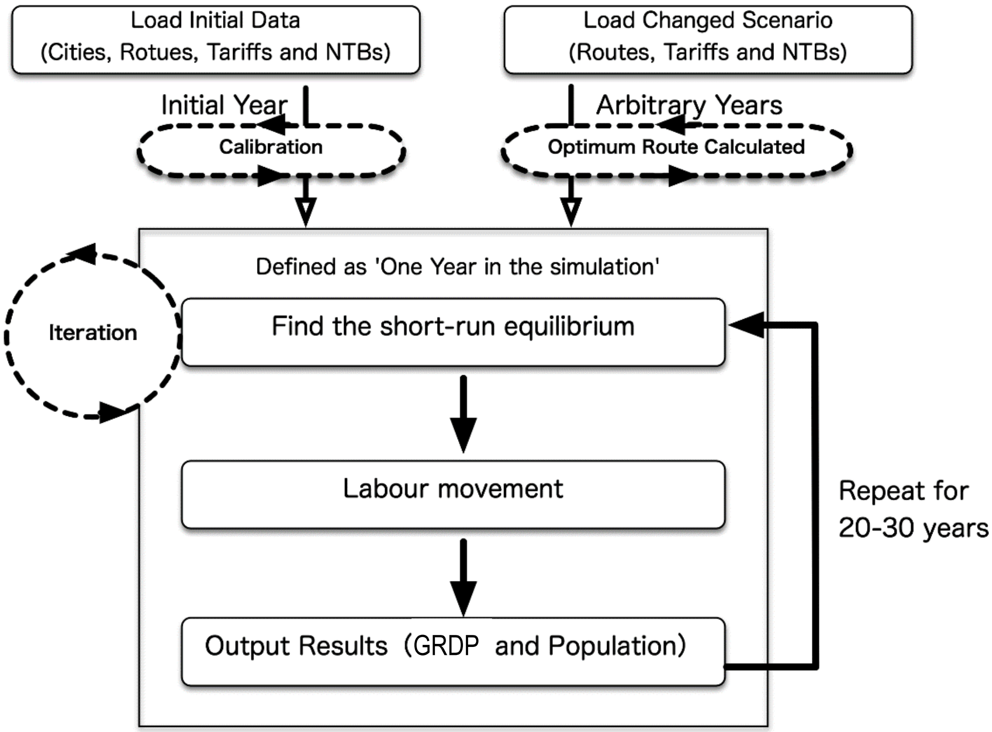
Parameters β, μ, and ρ are obtained as follows. The consumption share of consumers by industry (μ) is uniformly determined for the entire region in the model. It would be more realistic to change the share by country or region, but insufficiently reliable consumption data makes this impossible. Therefore, the consumption share by industry is set to be identical to the industry's share of GDP for the entire region as follows: 0.040 for agriculture, 0.033 for FoodProc, 0.018 for Textile, 0.026 for E&E, 0.020 for Auto, 0.172 for OtherMfg, and 0.687 for services. The single labour input share for each industry ($1 - \beta$) is uniformly applied for the entire region and the entire time period in the model. Although it may differ amongst 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 2005 by IDE and 'JETRO Survey on Business Conditions of Japanese Companies in Asia and Oceania 2013'[16]. As a result, the parameter of β is 0.39 for agriculture, 0.39 for FoodProc, 0.36 for Textile, 0.44 for E&E, 0.43 for Auto, 0.41 for OtherMfg, and 0.0 for services.

A5. Simulation Procedures

This section explains our simulation procedures, which are depicted in Figure 2. First, with given distributions of employment and regional GDP by sector and regions, short-run equilibrium is obtained. The equilibrium nominal wages, price indices, output, and GDP by region are calculated.

[16] This is an annual survey conducted by JETRO, known as 'Zai Asia Oceania Nikkei Kigyo Jittai Chosa' in Japanese.

Figure A2. Simulation Procedure



NTB = nontariff barrier, GRDP = gross regional domestic product.

Source: Authors.

Observing the achieved equilibrium, workers migrate amongst regions. Workers migrate from the regions with lower real wages to the regions with higher real wages. Within a region, workers move from lower-wage industries to higher-wage industries. One thing we need to note is that the process of this adjustment is gradual, and the real wages between regions and industries are not equalised immediately.

After the migration process, we obtain the new distribution of workers and economic activities. With this new distribution and predicted population growth, the next short-run equilibrium is obtained for a following year, and we observe the migration process again. These computations are iterated typically for 20 years from 2010 to 2030.

A6. Calculation of economic impacts

To calculate the economic impacts of specific trade and transport facilitation measures (TTFMs), we take the differences of GRDPs between the baseline scenario and a specific scenario with TTFMs. The baseline scenario contains minimal additional infrastructure development after 2010. On the other hand, the alternative scenario contains specific TTFMs in 2015, for example, according to the information on the future implementation plans of TTFMs.

We compare the GRDPs between two scenarios typically in 2030. If the GRDP of a region under the scenario with TTFMs is higher (lower) than that under the baseline scenario, we regard this surplus (deficit) as the positive (negative) economic impacts by the TTFMs.

A merit of calculation of the economic impacts by taking the difference between scenarios is the stability of the results. The economic indices forecasted by a simulation depend on various parameters while the differences of the economic indices are quite stable regardless of the changes of the parameters.

A7. Making scenarios

(1) Baseline scenario

The following assumptions are maintained in the baseline scenario:

- The national population of each country is assumed to increase at the rate forecast by the UN Population Division until the year 2030.
- International migration is prohibited.
- Tariff and non-tariff barriers are changing based on FTA/EPAs currently in effect.
- We give different exogenous growth rates on technological parameters for each country.

The final point should be noted precisely. In IDE–GSM, each industry in each city has a different productivity parameter '*A*'. We can interpret this parameter *A* containing the following factors:

- Education/skill level;
- Logistics infrastructure within the region;
- Communications infrastructure within the region;
- Electricity and water supply;

- Firm equipment; and
- Utilisation ratio/efficiency of infrastructure and equipment.

We give different exogenous growth rates for the productivity parameter '*A*' for each country to replicate the GDP growth trend from 2010 to 2023, which is estimated and provided in the World Economic Outlook by the International Monetary Fund. After 2023, we gradually reduce the calibrated growth rates of technological parameters to half in 20 years.

In the baseline scenario, transport settings are unchanged throughout the simulation period 2010–30, except for some minor updates in 2015. For instance, the average speed of land traffic is set at 38.5 km/h. However, the speed on roads through mountainous areas is set to half (19.25 km/h), and certain roads are set at 60 km/h—namely, roads in Thailand outside traffic-congested metropolitan Bangkok, the road from the border of Thailand to Singapore through the west coast of Malaysia, and roads No. 9 and No. 13 from Vientiane to Pakse in the Lao PDR. The average speed for sea traffic is set at 14.7 km/h between international class ports and at half that on other routes. Average air traffic speed is set at 800 km/h between primary airports of each country and at 400 km/h on other routes. Average railway traffic speed is set at 19.1 km/h.

(2) Trade and transport facilitation measures: TTFMs

We have various trade and transport costs in the model. By changing these costs, we can replicate the TTFMs in the model as follows:

- Upgrading of the road: increase in the average speed of cars for a road.
- Customs Facilitation: reduction of the time and money costs at the national borders.
- FTA/RTA: reduction of the import tariffs between member countries and reduce the NTBs with taking into account the 'cumulation' effect of FTA/RTA.
- Overall improvements in business environments: reduction of NTBs for a country.

(3) Special economic zone and a free trade zone

In the model, each industry in each city has a different productivity parameter *A*. The increase in this regional productivity captures the improvements in investment climates included in *A*. Such practical examples include the establishment of special economic zone/free trade zones.

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