Background Papers 5

A Geographical Simulation Analysis of the Impacts of the Trilateral and its Eastward Extensions

By So Umezaki and Satoru Kumagai

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Background paper

So Umezaki and Satoru Kumagai

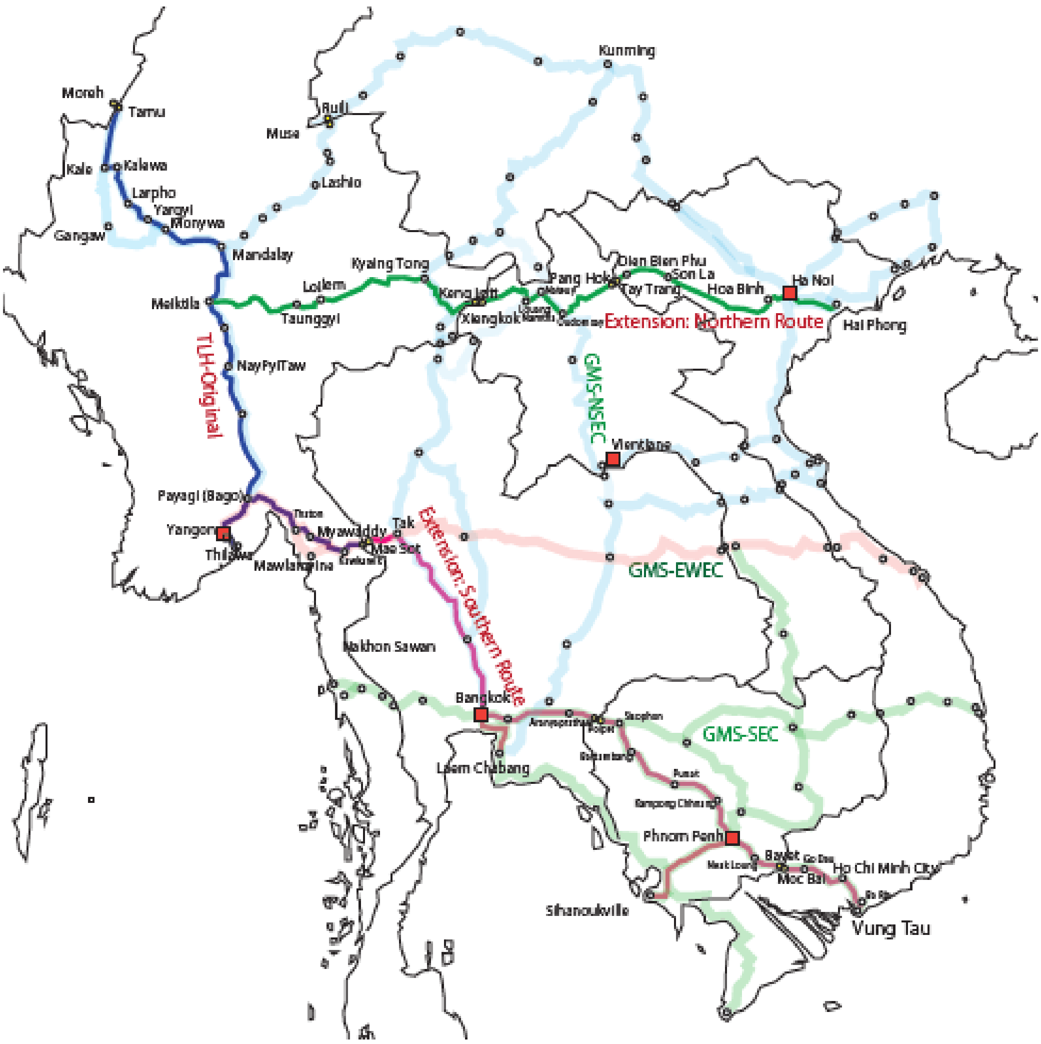
Maps shown in the study are not to scale. All maps shown in this study are only for demonstrative and study purpose. The shape and boundaries and borders of countries/states shown here do not represent the actual size and shape of countries/states, and the actual size, shape and borders of domestic,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

1. Introduction

The India–Myanmar–Thailand Trilateral Highway (TLH) was first conceived at the Trilateral Ministerial Meeting on Transport Linkages in Yangon in April 2002, where India, Myanmar, and Thailand agreed to make all efforts to establish trilateral connectivity by 2016. Since then, particularly after the change of government in Myanmar in 2011, progress has been made in the development of the TLH, including the opening of a new Myawaddy–Kawkareik bypass road (Thailand–Myanmar side) in 2015 and Integrated Check Post (ICP) at Moreh (India) in January 2019. The latter, however, is yet to be fully operational. The TLH is still a project under construction, and, therefore, its contribution to the economic growth and development of the region has not yet reached its potential.

Under the circumstances, the countries concerned started to consider the possibility of extending the TLH eastward to connect to the Lao People's Democratic Republic (Lao PDR), Cambodia, and Viet Nam. At the 16th ASEAN Highways Sub-Working Group Meeting (16th AHSWG) in August 2018, the Thai government proposed two potential routes for the eastward extension. As illustrated in Figure 1, the northern route branches off the original TLH at Meiktila in central Myanmar, runs eastward through Loilem, Kyaing Tong, and Keng Latt, then crosses the border at the Myanmar–Lao PDR Friendship Bridge to Xieng Kok in the Lao PDR. It then runs through Louang Namtha, Oudomxay, and Pang Hoc, crosses the border to enter Tay Trang in Viet Nam, runs through Dien Bien Phu, Son La, Hoa Binh, Ha Noi, and connects to Hai Phong. The southern route is a direct extension from Mae Sot in Thailand, the terminal point of the TLH, and runs through Tak, Nakhon Sawan, Bangkok, Hinkong, Kabinburi, and Aranyaprathet. It crosses the border to Poipet in Cambodia, runs through Sisophon, Battambang, Kampong Chhnang, Phnom Penh, Neak Loung, and Bavet, crosses the border to Moc Bai in Viet Nam, runs through Go Dau, Ho Chi Minh City, Ba Ria, and connects to Vung Tau. The southern route has two branch routes to establish connectivity to international ports, one from Bangkok to Laem Chabang and the other from Phnom Penh to Sihanoukville.[1]

Figure 1. Trilateral Highway and Eastward Extension Routes



Source: Drawn by Authors based on ADB (2018b).

[1] The southern extension route overlapped with economic corridors under the Greater Mekong Subregion Cooperation (GMS) Programme led by the Asian Development Bank (ADB). The section between Mae Sot and Tak is on the East–West Economic Corridor (EWEC); the section between Tak and Bangkok is on the North–South Economic Corridor (NSEC); and the remaining sections are on the Southern Economic Corridor (SEC).

The objective of this study is to investigate the expected economic impacts of the development of the TLH and its eastward extension using the Institute of Developing Economies/Economic Research Institute for ASEAN and East Asia Geographical Simulation Model (IDE/ERIA–GSM).[2]

2. Model and Scenarios

2.1. IDE/ERIA–GSM

Since 2007, IDE–JETRO has been developing the IDE–GSM. The theoretical foundation of the IDE/ERIA–GSM, which is co-developed with ERIA, follows 'new economic geography', in particular Puga and Venables (1996), who captured the characteristics of multi-sector and country general equilibrium.[3]

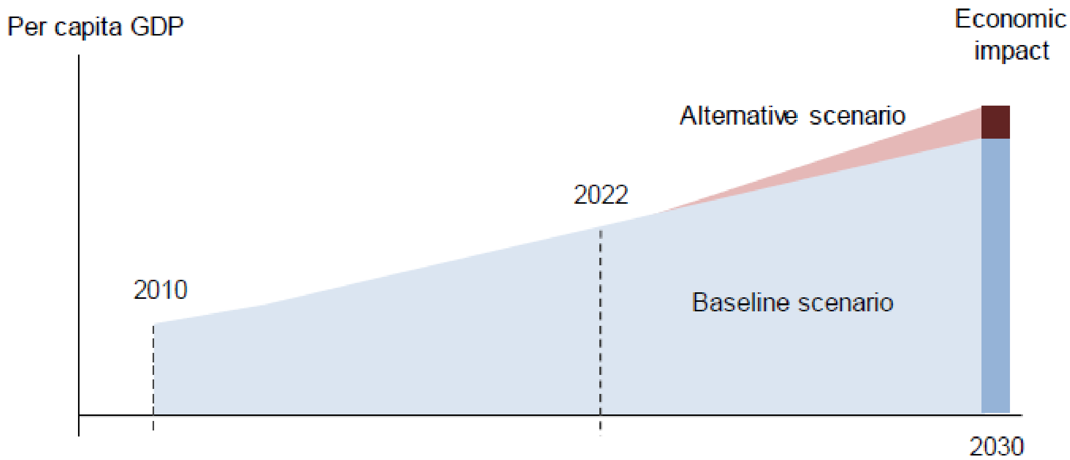
The IDE/ERIA–GSM features agriculture, five manufacturing sectors (automotive, electric and electronics, apparel, food processing, and other manufacturing), and the services and mining sectors. The model allows workers to move within countries and between sectors with frictions. A notable difference between the IDE/ERIA–GSM from that of Puga and Venables (1996) lies in the specification of the agricultural sector. The IDE/ERIA–GSM explicitly incorporates land size in its 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 interests. It also incorporates the impact of policy measures to facilitate international transactions on the magnitude and location of trade traffic. These enable us to identify potential bottlenecks and how to reap the full benefits of economic integration. The basic structure of IDE/ERIA–GSM is depicted in Figure A1 in the Appendix. Each region possesses eight economic sectors, namely agriculture, mining, five manufacturing sectors, and the services sector.

Figure 2 shows the differences in gross regional product (GRP) between the baseline scenario and alternative scenarios through calculating the economic impact of the development of various logistics infrastructure. The baseline scenario assumes national and regional growth based on official statistics and international organisation estimations after 2010. The alternative scenario assumes that several logistics infrastructures (expressways) will be completed by 2025. We compare the GRP between these two scenarios in 2030. If the per capita GRP of a region under the scenario with specific criteria is higher (lower) than that

[2]A recent and comparable application of the IDE/ERIA–GSM is Keola and Kumagai (2019), who investigate the economic impacts of the Vientiane–Hanoi Expressway.
[3]The earlier version of IDE/ERIA–GSM is explained in Kumagai et al. (2013). For further details of the IDE/ERIA–GSM, see the Appendix of this paper.

under the baseline scenario, we regard this surplus (deficit) as a positive (negative) economic impact of the development of logistics infrastructure. 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 the GRP of a region or an industry would actually shrink compared to its current size. Instead, it just means that they would be smaller than what they might have expanded to, i.e. the baseline. More precisely, suppose the results predict 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 2025 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 2. Difference between the Baseline and Alternative Scenarios



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

2.2. Baseline and Alternative Scenarios

We conduct a simulation analysis of the following five alternative scenarios. In the IDE/ERIA–GSM, the quality of road infrastructure is categorised into four classes in terms of the average speed to connect one point with another. The average speed on road segments with standard quality is set at 38.5 kilometres per hour (km/h).[4] The status quo of the road infrastructure is classified with reference to the recent assessment of the GMS Economic Corridors by 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 the road infrastructure; the first and the second stages represent 'moderate improvement' and 'significant improvement' to increase the average

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

speed to 38.5 km/h and 60.0 km/h, respectively.[5]

Based on the updated information on the status of the TLH and its potential extension routes obtained through our stocktaking studies, we set the baseline scenario 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 (115 km), (ii) Thaton–Hpa-An (51 km), (iii) Hpa-An–Eindu (20 km), and (iv) Eindu–Kawkaleik (71 km). Road sections under 'poor' quality along the eastward extension routes are (v) Payangazu–Kalaw (76 km), (vi) Taunggyi–Loilem (91 km), (vii) Loilem–Takaw (177 km), (viii) Takaw–Kentung (190 km), (ix) Tarlay–Kyainglat (56 km), (x) Xieng Kok–Muang Sing (69 km) in the Lao PDR, and (xi) Tay Trang–Na Thin (19.2 km) in Viet Nam. Except for (x) and (xi), all 'bad' quality sections are in Myanmar. In addition, reflecting the fact that the Myanmar–Lao PDR Friendship Bridge, the border between Kyainglat 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 the Lao PDR, meaning that Myanmar cannot export to the Lao PDR through the bridge. In addition, Myanmar cannot import through the bridge wherever the origin countries are. These are the elements of the status quo.

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

Most of the 'bad' quality sections have already been undergoing upgrading or improvement works with specific timelines for completion. The information on the design standards and timelines is reflected in alternative scenarios as the already prescribed future. Specifically, the following are included in this scenario.

- [Myanmar] The Kalewa–Yargyi section will be upgraded (class 2 → class 3) in 2022 and beyond, reflecting the fact that the upgrading work is planned to be completed in May 2021.
- [Myanmar] The 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] The Thaton–Hpa-An–Eindu section will be upgraded (2 → 3) in 2025 and beyond, reflecting the ongoing and planned upgrading work by ADB and Thailand.
- [Myanmar] The 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 Kawkaleik Bridge is planned to be completed in May 2021.

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

- [India/Myanmar] Improvements in border-crossing procedures at the Moreh/Tamu border in 2021 and beyond.
- [Myanmar/Thailand] Improvements in border-crossing procedures at the Myawaddy/Mae Sot border in 2021 and beyond.

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

- Scenario 1
- [Myanmar] The Payangazu–Kalaw section will be upgraded (2 → 3) in 2021 and beyond, based on the observation of ongoing improvement work.
- [Myanmar] The Taunggyi–Loilem–Ta kaw–Keng Tung 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] The Tarlay–Kyainglat 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, which was revealed in June 2019.[6]
- [Lao PDR] The Xieng Kok–Muang Sing section will be upgraded (2 → 3) in 2025 and beyond.
- [Viet Nam] The 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 the Pang Hoc/Tay Trang border in 2021 and beyond.

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

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

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

- Scenario 1

[6]ASEAN Secretariat, 'ASEAN identifies potential infrastructure projects,' Press Release, 10 June 2019. 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.

- [Thailand/Cambodia] Improvements in border-crossing procedures at the Ban Khlong Luek/Poipet border in 2021 and beyond.
- [Cambodia/Viet Nam] Improvements in border-crossing procedures at the Bavet–Moc Bai border in 2021 and beyond.

Scenario 4a **All**

- Scenario 2b
- Scenario 3

Scenario 4b **All (challenging)**

- Scenario 4a
- [All] Upgrade all TLH and eastward extension sections to 'highway quality' (3 → 4), enabling trucks to drive at 60.0km/h on average.

3. Simulation Results and Implications

3.1. By Country

The simulation results are shown in Figures 3 and 4. Tables 1–6 illustrate more details of the results of scenarios S1–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 3) and percentage (Figure 4), as expected from the fact that most of the TLH is in Myanmar's territory. Second, the impact of the internationalisation of the Myanmar–Lao PDR Friendship Bridge is very small, indicating that the potential demand for transportation crossing the border is limited. Relating to this point, the expected impact on the Lao PDR is small. Third, the comparison between 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 crucially 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 the 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 Myanmar's territory, Myanmar is expected to enjoy most of the gains from the TLH, 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 Kawkaleik, which used to be the most significant bottleneck for 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' (Greater Mekong Subregion Secretariat, 2018). 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 the northern route (S2b), where the total gain in GDP in India, Myanmar, and Thailand amounts to US$677 million (Table 3), which is significantly more than US$509 million, the comparative figure for the southern route (S3) (Table 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 the 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 the internationalisation of the Myanmar–Lao PDR Friendship Bridge is marginal, implying that the potential demand for trade across the 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 the Lao PDR. Again, it is important for Myanmar and the Lao PDR to examine deliberately the balance of the costs and benefits to realise this scenario (S2b).

Tables 3 and 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 gains for India, Myanmar, and Thailand in S2b are US$677 million, which comprises 98.7% of the total gains for the six countries. That is, the expected gains for Cambodia, the 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, at US$97 million and US$68 million respectively (Table 4). That is, the southern route is much more preferable for Cambodia and Viet Nam, and the same for Lao PDR to a lesser extent, than the northern route. In addition, the expected impacts of the northern and southern routes need to be compared while taking the necessary costs into account. The southern route does not require additional costs to improve the 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 among 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 5). The additional scenario (S4b) to upgrade all routes to highway standard is expected to magnify the impacts to all six countries (Table 6). Again, these results need to be evaluated together with the cost consideration.

Figure 3. Impacts by Country (US$ million, difference vs. baseline)

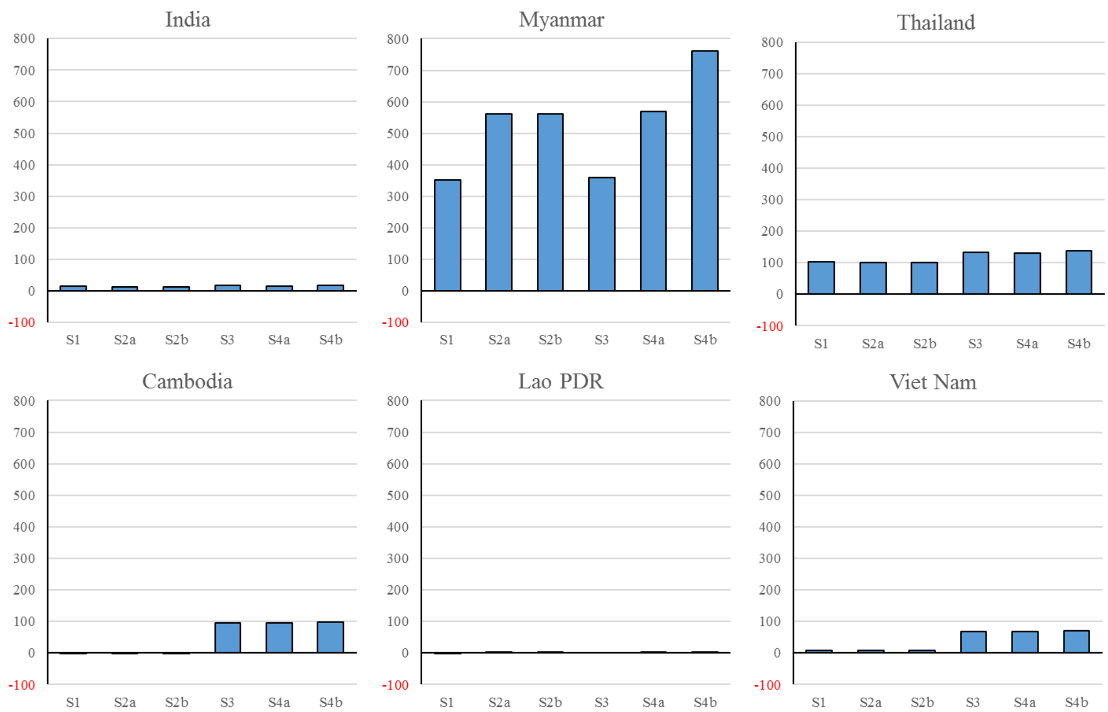


Figure 4. Impacts by Country (%, difference vs. baseline)

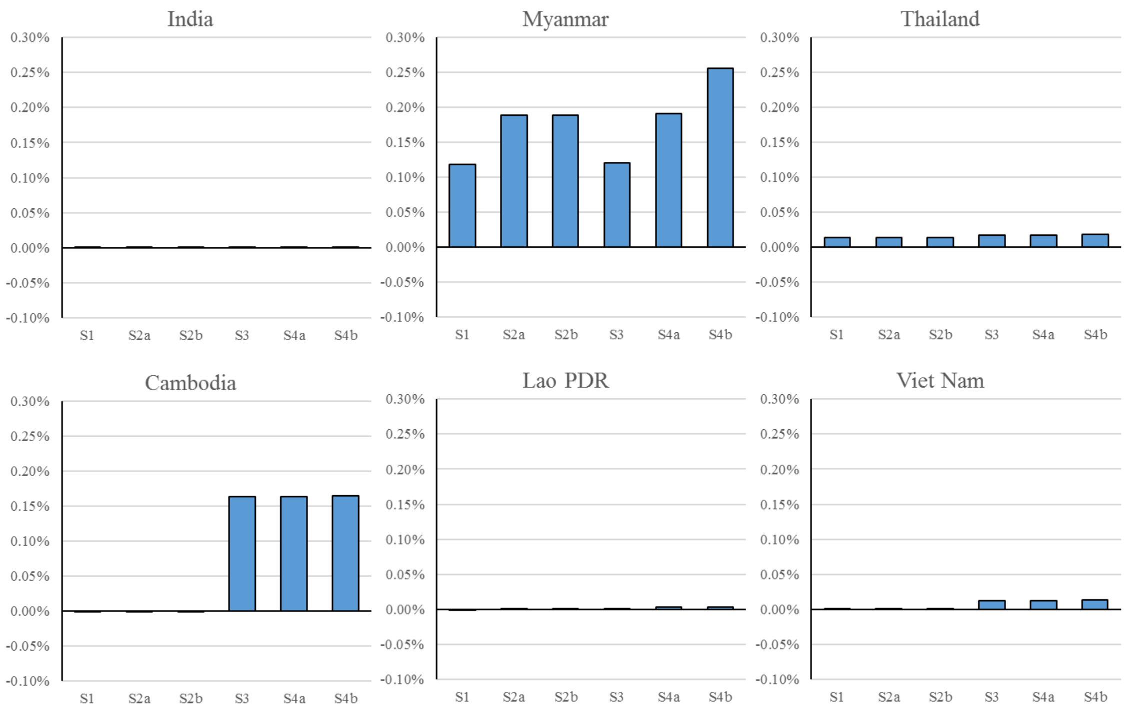


Table 1. Results of S1 by Country and Industry (US$ million)

	Agriculture	Automotive	Electrics & 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

Note: IMT = India, Myanmar, and Thailand; CLV = Cambodia, Lao PDR, and Viet Nam; EA16 = 10 ASEAN Member States, plus Australia, China, India, Japan, the Republic of Korea, and New Zealand. Black triangles (▲) indicate negative numbers.

Table 2. Results of S2a by Country and Industry (US$ million)

	Agriculture	Automotive	Electrics & 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

Note: IMT = India, Myanmar, and Thailand; CLV = Cambodia, Lao PDR, and Viet Nam; EA16 = 10 ASEAN Member States, plus Australia, China, India, Japan, the Republic of Korea, and New Zealand. Black triangles (▲) indicate negative numbers.

Table 3. Results of S2b by Country and Industry (US$ million)

	Agriculture	Automotive	Electrics & 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

Note: IMT = India, Myanmar, and Thailand; CLV = Cambodia, Lao PDR, and Viet Nam; EA16 = 10 ASEAN Member States, plus Australia, China, India, Japan, the Republic of Korea, and New Zealand. Black triangles (▲) indicate negative numbers.

Table 4. Results of S3 by Country and Industry (US$ million)

	Agriculture	Automotive	Electrics & 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

Note: IMT = India, Myanmar, and Thailand; CLV = Cambodia, Lao PDR, and Viet Nam; EA16 = 10 ASEAN Member States, plus Australia, China, India, Japan, the Republic of Korea, and New Zealand. Black triangles (▲) indicate negative numbers.

Table 5. Results of S4a by Country and Industry (US$ million)

	Agriculture	Automotive	Electrics & 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

Note: IMT = India, Myanmar, and Thailand; CLV = Cambodia, Lao PDR, and Viet Nam; EA16 = 10 ASEAN Member States, plus Australia, China, India, Japan, the Republic of Korea, and New Zealand. Black triangles (▲) indicate negative numbers.

Table 6. Results of S4b by Country and Industry (US$ million)

	Agriculture	Automotive	Electrics & 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	1,082.90
ASEAN10	39.29	16.16	0.13	111.97	481.02	▲ 3.96	432.64	0.76	1,078.02
EA16	69.47	11.03	1.05	92.98	424.84	7.30	469.10	1.62	1,077.40

Note: IMT = India, Myanmar, and Thailand; CLV = Cambodia, Lao PDR, and Viet Nam; EA16 = 10 ASEAN Member States, plus Australia, China, India, Japan, the Republic of Korea, and New Zealand. Black triangles (▲) indicate negative numbers.

3.2. By Country and Industry

As shown in Table 1, the completion of the original TLH (S1) is expected to increase the 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$393.2 million), of which the food processing sector (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 the 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, the agriculture sector is expected to gain the most (US$23.5 million), part of which will be offset by the expected decline in the manufacturing sector (▲US$8.8 million). The expected impacts on Cambodia and the 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 the Lao PDR. In this line of discussion, China is the biggest loser in S1 as its real GDP is expected to decrease by US$33.5 million from the baseline in 2035. Most of the negative impacts are found in the food processing sector (▲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) significantly in Myanmar by 59.7% from US$351.6 million to US$561.6 million (Table 1 and Table 3). The Lao PDR and Viet Nam will gain, but the impacts are small. In this scenario, Thailand (US$101.3 million) is the second-largest beneficiary after Myanmar, followed by India (US$13.6 million), and the positive impacts are slightly smaller than in S1. Although a major part of the expected gains in Myanmar can be attributable to the food processing sector (52.4%), in this scenario, the service sector will contribute significantly (43.2%, 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 1). The positive impact on India is contributed mainly by agriculture (176.5%), a large part of which will be offset by the negative impacts on the manufacturing and services sectors. The impacts of the northern extension route on Cambodia are negligible. Although China will be negatively affected, the negative impacts are 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 4). The additional impacts on India, Myanmar, and Thailand are all positive, but in favour of India and Thailand. Compared with S1 (Table 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 in the northern route. As illustrated in Figure 1, the section between Mae Sot and Tak is a part of the EWEC, the section between Tak and Bangkok is a part of the NSEC, and the remaining sections are on the SEC. 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 through the 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 cost of the Lao PDR, which will benefit only a small amount (US$0.5 million). Viet Nam is expected to be the fourth largest beneficially (US$67.9 million) after Myanmar (US$358.5 million), Thailand (US$133.2 million), and Cambodia. The total gain of the six countries (IMT+CLV) 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 the Lao PDR, the expected impacts of eastward extension routes, both northern and southern, are very small and the difference is negligible. In this case, a cost–benefit consideration may lead the Lao PDR not to invest in upgrading the northern extension route because it would cause a certain amount of costs, while the expected benefit is small. Also, from a regional perspective, it should be noted that the costs for road improvement will be smaller in the case of the southern extension route because most of the necessary improvements have already been done.

Tables 5 and 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 on S2b and S3 can be mitigated significantly.

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

3.3. By sub-national region

A major benefit of the IDE/ERIA–GSM is that it can estimate the economic impacts on a sub-national level. This sub-section visually illustrates the simulation results of scenarios 1–4b. At first glance, two important implications can be drawn from Figures 5–10. 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 already 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 impact in US dollar 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 and most significantly affected (▲US$3,647/$km^2$), probably because several economic activities are attracted to Mandalay and the surrounding provinces where the business environments will be improved, particularly from the logistics perspective. 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 a relative deterioration of the investment climate in other provinces. Although the total impact on Myanmar is positive, an uneven distribution of the gains may cause difficulties in implementation. Indeed, this can be a serious bottleneck in Myanmar, where regional disparities already prevail, and the uneven distribution of the economic impacts could worsen the existing ethnic conflicts. In India, several regions in the Northeast Region (NER), particularly those in Assam and Manipur, are expected to gain, although the positive impacts are small. In Thailand, several regions far away from the TLH will be affected significantly, namely Samut Prakarn (US$19,091/km^2), Samut Sakhon (US$15,661/km^2), Bangkok (US$11,234/km^2), 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 in Thailand.

Figure 5. Impact Density of S1 on Sub-National Regions

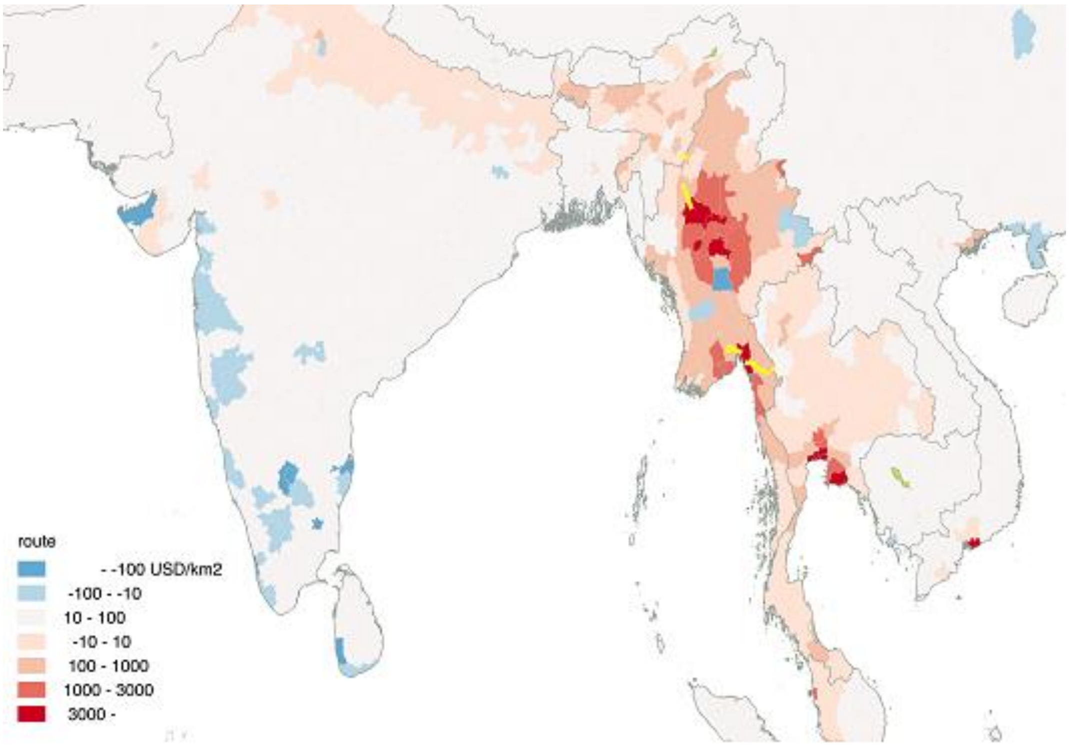


Figure 6. Impact Density of S2a on Sub-National Regions

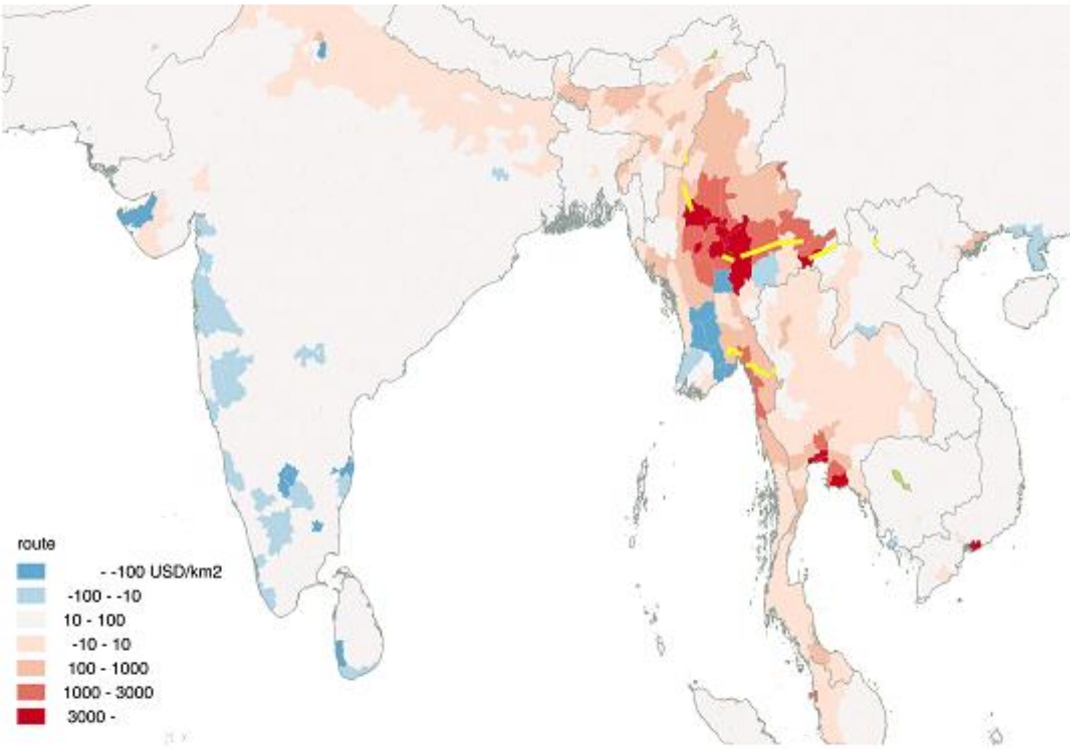


Figure 7. Impact Density of S2b on Sub-National Regions

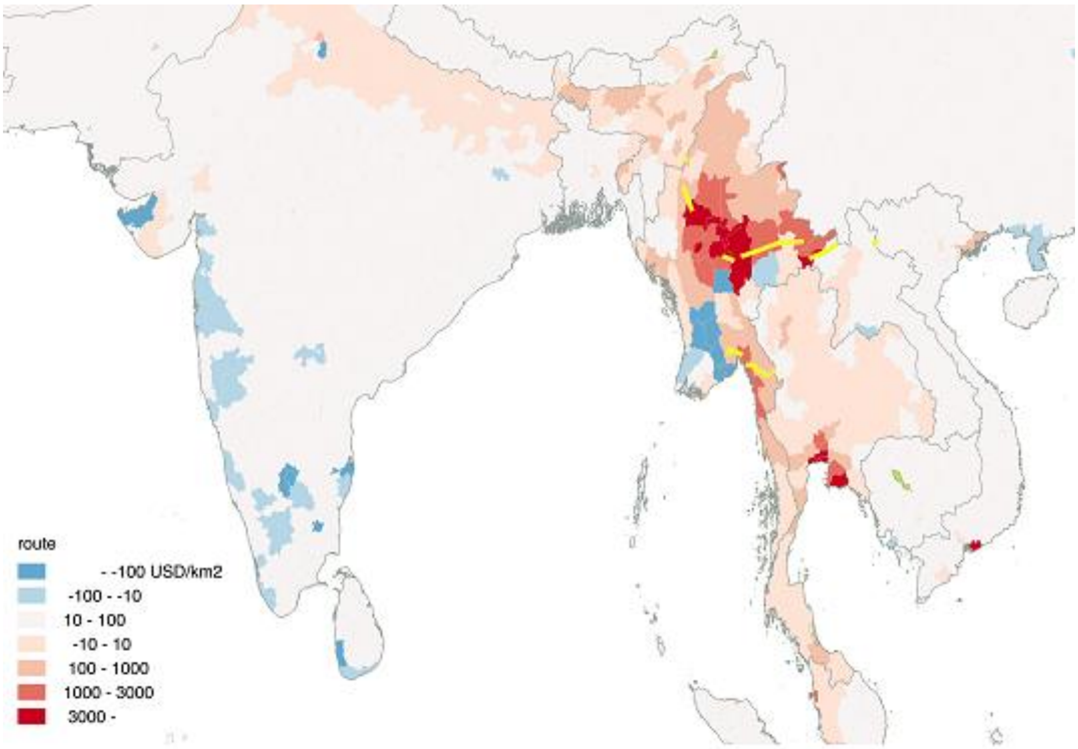


Figure 8. Impact Density of S3 on Sub-National Regions

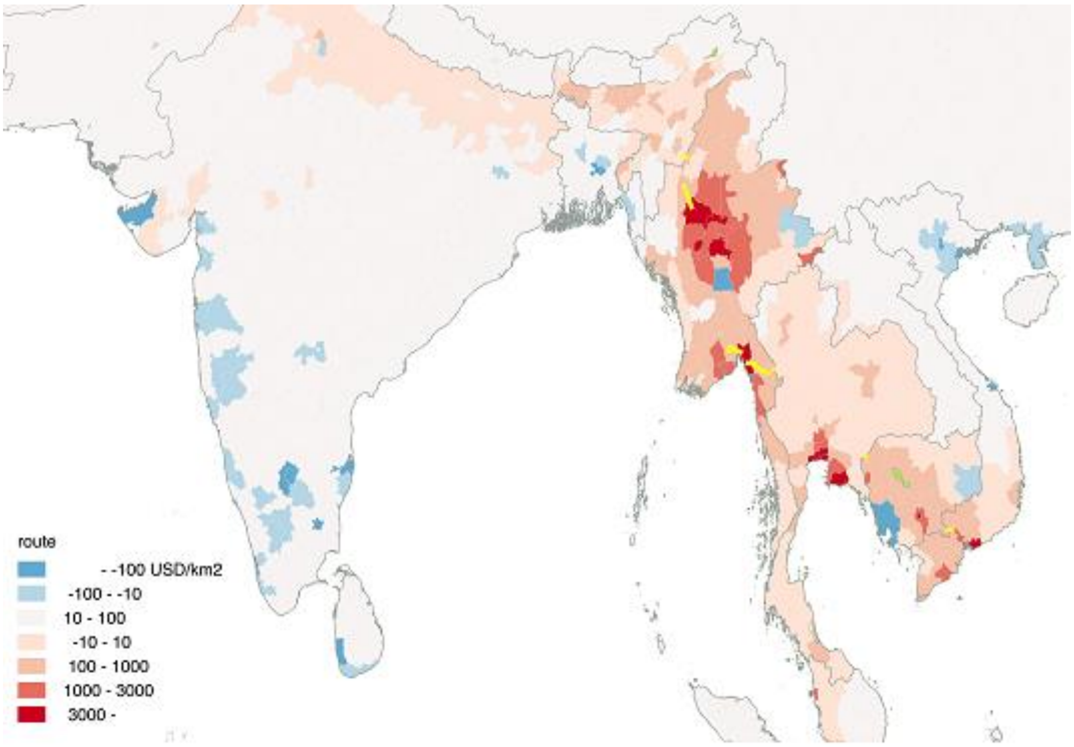


Figure 9. Impact Density of S4a on Sub-National Regions

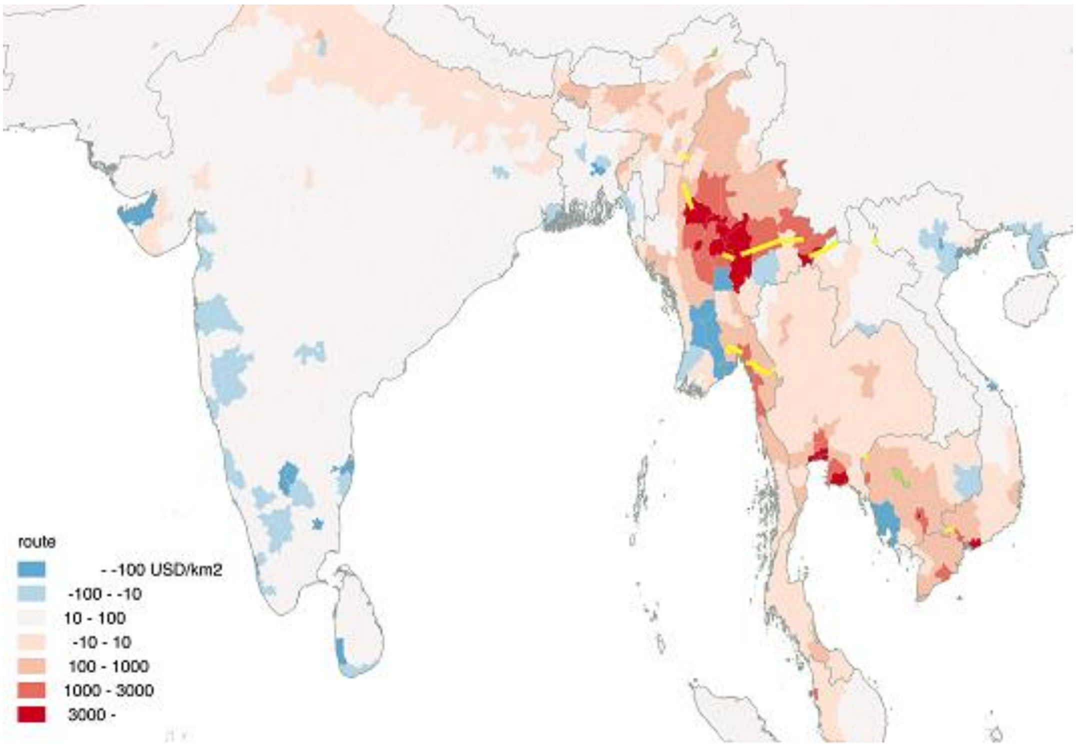
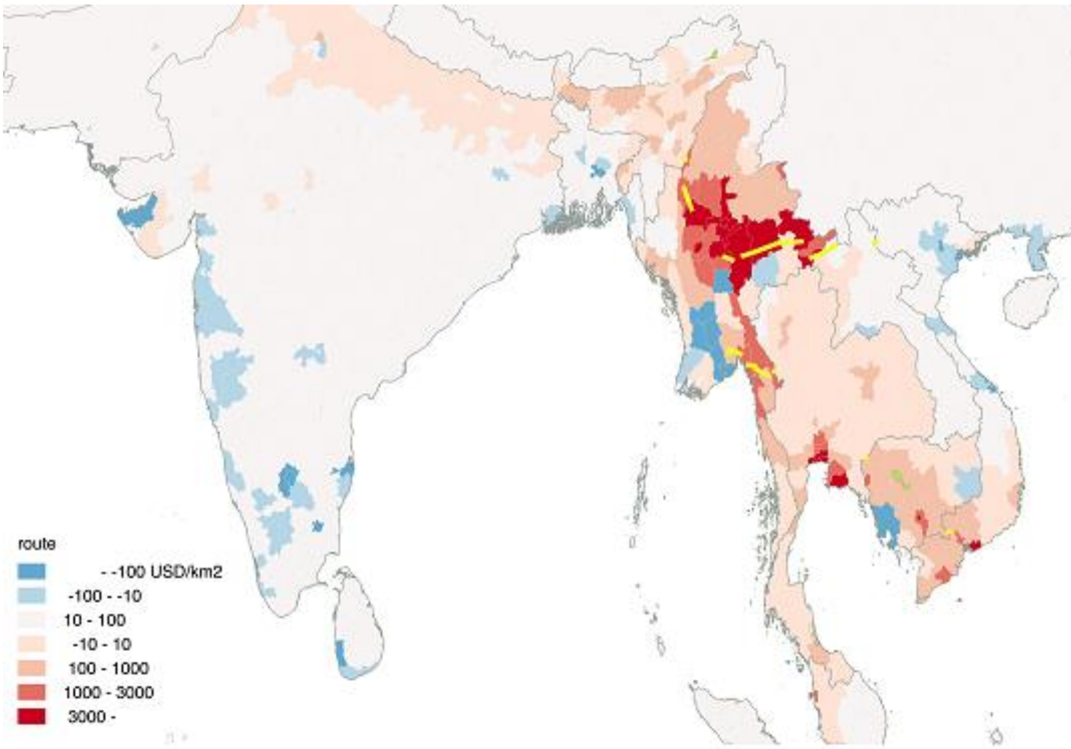


Figure 10. Impact Density of S4b on Sub-National Regions



It is important to highlight that several regions far away from the scope of the TLH could be significantly 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 significantly the neighbouring regions (Figure 7). Mandalay (US$32,506/km^2) maintains its position as 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), and these are expected to gain significantly 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 be 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 from other parts of the country, including Yangon.

The northern provinces in the Lao PDR and Viet Nam will also be positively affected. In the 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), Hanoi (US$94/km^2), and Haiphong (US$12/km^2) will be positively affected in both comparisons with the baseline and S1.

The southern extension route (S3) will have more significant and wider impacts on provinces in Thailand, Cambodia, and Viet Nam than the case of the northern extension route, probably because it establishes a connection to already better-developed road networks (Figure 8). 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 will be positively and very significantly affected (US$203,542/km^2) as compared to US$81/km^2 in the case of S1, mainly led by the impacts on the textile sector. In Viet Nam, Ba Ria–Vung Tau will have the largest impact (US$22,023/km^2).

The 'all' development scenario (S4a) will of course have the largest and most widespread economic impacts on the region as a whole. In Myanmar, the large cities along the TLH, 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, the metropolitan cities in the north, Hanoi (▲US$973/km^2) and Hai Phong (▲US$209/km^2), will be slightly but negatively affected. Regions along the northern extension route will be positively affected, such as Tachileik (US$12,958/km^2), Taunggyi (US$5,018/km^2), Kengtung (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) and Louang Namtha (US$1,355/km^2) in the Lao PDR. These relatively less-developed regions in less-developed countries such as Myanmar and Lao PDR have been facing difficulties in economic growth due mainly to the weak connectivity to 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 important opportunities for these provinces to embark on economic development, led mainly by the food processing, services, and agriculture industries.

In Thailand, the biggest positive impact is expected in Bangkok and the surrounding regions, and the impacts are significantly bigger than those under S1. In India, the 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 the NER of 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; 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.

3.4. Impacts on Narrowing the Development Gaps

As discussed above, the upgrading of the road infrastructure and improving the border-crossing 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), other regions may experience positive impacts even though the region is far away from the route, as we observed in Thailand and Viet Nam. That is, the impacts of the transport corridors are expected to spread to wider regions differently. In order to investigate the distributional consequences of the development of the TLH and its eastward extensions, we computed a variant of the Gini coefficient using the simulation results, which contain estimates of the gross regional domestic products (GRDP) and population in each region. In the calculations, we assume perfect equality in each region.

Table 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

Source: Authors' computation based on the simulation results.

As shown in Table 7, the distributional impacts of each scenario are very small. Although the impacts of each scenario differ by region, the distributional impacts are almost invisible because the additional impacts generated by each development scenario are expected to be too small.

4. Conclusions and Policy Recommendations

Important implications from this simulation analysis can be summarised as follows.

First and foremost, the expected impact of the TLH, including its eastward extensions, is not large in terms of both increasing GDP and narrowing the development gaps in the region. This is mainly because of the lack of strong economic agglomeration along the route. Although Bangkok, Ho Chi Minh City, and Hanoi are included in the eastward extension routes, they are located on only one side of the original alignment of the TLH. In order to transform a transport corridor into 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 NER of India can only be explored through a series of pragmatic policies to untangle various bottlenecks.

Second, Myanmar is the largest beneficiary in the TLH and its extension routes, reflecting the fact that most of the original alignment of the TLH is in Myanmar's territory. Thailand is the second beneficiary, and 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 for the NER of India.

Third, although the additional impacts caused by the northern extension route and by the southern extension route are more or less similar in terms of the total amount, the distributional implications differ substantially. If we compare only in terms of the expected economic impacts, Myanmar would prefer the northern extension route and others would 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 cost of negative impacts on other parts of the countries or regions. In order to pursue both economic growth and the narrowing development gaps, therefore, 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 countries.

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, which is usually equivalent to a lower level of economic development, the larger is the potential to enjoy positive economic impacts in the region. The large economic impact induced by the northern extension route is probably because it passes through the Shan State

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

of Myanmar, where economic development is still in the early stages, reflecting weak connectivity to neighbouring countries. The other aspect is drawn from the comparison between S4a and S4b, that the larger the improvement in the road quality, the larger the expected economic impacts will be. In both cases, the degree of improvement in road infrastructure depends on the size of investment. The northern extension route will require larger investment in improving road infrastructure because it needs to start from the lower status quo. In contrast, the southern extension route has already been better developed as GMS economic corridors and, therefore, the necessary improvement is much smaller than the northern extension route. Similarly, constructing a highway-quality road requires bigger investment than constructing a standard-quality road.

These are important issues for policy considerations to balance the costs and benefits. Given the relatively fragile security condition in some parts of Myanmar and India, it is important for policy makers to consider the distributional consequences of corridor development in addition to the usual concerns on the total return on investment. As already discussed above, the country-wise distribution of the expected economic impacts 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 the road infrastructure along the Thai side of the TLH because it is expected to generate economic benefits for Thailand as well as Myanmar. This is also true for India in its assistance to develop the Kalewa–Yargyi section of the TLH. How about the case of the northern extension route? As Myanmar is the only expected beneficiary, it might be difficult to expect bilateral assistance from neighbouring countries as those donors need to pay particular 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 dare to share a common vision to develop a second EWEC to open long-aspired opportunities for the remaining less-developed regions, namely the Shan State of Myanmar, northern provinces in the Lao PDR, and northwestern parts of Viet Nam. In a recent review of the configuration of the GMS economic corridors, ADB (2018b, 2018i) identifies several sub-corridors in the NSEC based on an extensive assessment of the whole system of the GMS Economic Corridors (ADB, 2018a–h). Despite its timely and promising progress, the connectivity among the sub-corridors of the NSEC seems to be weak because of the lack of a route skewering the sub-corridors in an east–west direction. Developing the northern extension route of the TLH as a second EWEC would enhance the impacts of the sub-corridors of the NSEC by generating synergies from having multiple choices for trade routes.[8]

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

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Appendix: System of the IDE–GSM

Satoru Kumagai, IDE–JETRO

Introduction

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

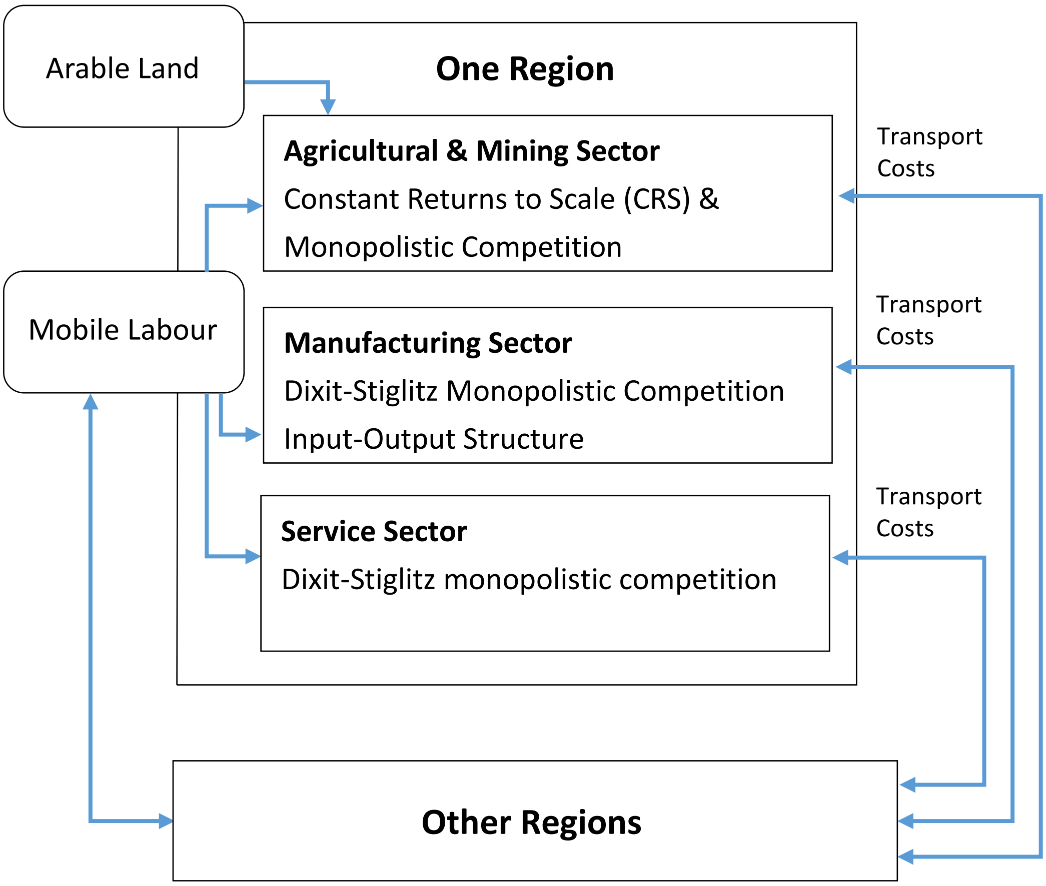
The main objective of the IDE–GSM is to analyse regional dynamics in population and economic growth with and without specific infrastructure projects. It allows impact analysis on the regional economies at the subnational level. IDE–GSM can help to prioritise various infrastructure development projects and offer an objective evaluation tool for policy recommendations in infrastructure development.

The analysis typically shows the difference with and without projects, in other words, with scenarios and benchmark cases. This comparison clearly shows the impacts of specific scenarios and makes it easy to compare the scenarios, namely, development projects. By comparing scenarios by each scenario or by some sets of them, it is possible to access the possible best combination.

The Model[a]

Our model is multi-regional and multi-sectoral.[b] 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.

The theoretical foundation follows Puga and Venables (1996), who capture the multi-sector and country general equilibrium of NEG. Therefore, the explanation below mainly pertains to equations in equilibrium. However, it is noteworthy that our model differs from that of Puga and Venables (1996) in the specifications of the agricultural sector. We have explicitly incorporated land size in its production and keep its technology as constant returns to scale.[c]

[a] The model is a modified version of Kumagai and Isono (2011)
[b] For other simulation analysis based on 'new economic geography' (NEG), see Teixeira (2006) and Roberts et al. (2012).
[c] For detailed derivations, see Puga and Venables (1996) and Fujita, Krugman, and Venables (1999).

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 an area to another, a good with less than one unit arrives. Depending on the lost part, the supplier sets a higher price. The increase in price compared to the price of the producer is considered as the transport cost. Transport costs within the same area are considered negligible.

Our 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 sectors 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 services industry.

Regional incomes in the NEG 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 the manufacturing sector and the services sector at location *i*, and L_{Ji} is the labour input of the manufacturing sector and the services sector at location *i*, p_{Hi} is the price of an agricultural/mining product at location *i*, f_{Hi} is the agricultural/mining products at location *i*, respectively. TA_i is the re-distributed 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 production at location *i*, α_I is the labour input share for production, μ_I is the consumption share of products, A_{Ii} is a productivity parameter for location *i*, $T_I(j,i)$ stands for the iceberg transport costs from location *j* to location *i*, and σ_I is the elasticity of substitution between any two differentiated manufactured goods for agricultural, manufactured, and services goods, respectively. Nominal wages in the agricultural sector, manufacturing sector, and services sector 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 regional GDP, 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.

Data

Data for the IDE/GSM cover 98 countries/economies and 71 'rest of the world' countries/economies. The 98 countries/economies are divided into more than 3,065 regions, and we utilise country data for the rest of the world. In total, we have 3,136 regions in the model. Primarily based on official statistics, we derive regional-level GDP (RGDP) for the agricultural sector and mining sector, five manufacturing sectors, and the services sector for 2010. The five manufacturing sectors are the automotive (Auto), electronics and electric appliances (E&E), garment and textile (Textile), food processing (FoodProc) and other manufacturing (OtherMfg) sectors. The 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, the Republic of Korea, the 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, respectively. For the United States, the administrative unit is the state level, while for the European Union, the administrative unit is the NUTS-2 level in this version of the IDE–GSM.

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 kilometre, 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 (2008) of 'ASEAN Logistics Network Map 2008' and by estimating the model of the firm-level transport mode choice with the 'Establishment Survey on Innovation and Production Network'[d] 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 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 among the following three: air, sea, and land:

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

where ε_M denotes unobservable mode characteristics, while $Abroad_{ji}$ takes unity if regions i and j belong to different countries and is zero otherwise; d_{ji} is the geographical distance between regions i and j. u_s is an 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:

[d] This survey was conducted by the Economic Research Institute for ASEAN and East Asia (ERIA).

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

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, 'truck' is the 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 times 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, the 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 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 among industries. Such differences among industries are controlled by introducing the intercepts of industry dummy variables (u_s) with distance variables. Secondly, the level of port infrastructure is obviously different among countries. This yields different impacts of the aforementioned two kinds of transport costs among shipping countries. To control such differences among the countries in which the reporting firms locate, we introduce country dummy variables (v_k). Lastly, qualitative differences between intranational and international transactions are controlled by introducing a binary variable (*Abroad*), taking unity if transactions are international ones and zero 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 A1). The four countries covered in the survey are Indonesia, the Philippines, Thailand and Viet Nam. The sample population is restricted to selected manufacturing hubs in each country (the

Jabodetabek area, i.e. Jakarta, Bogor, Depok, Tangerang, and Bekasi, for Indonesia; the Calabarzon area, i.e. Cavite, Laguna, Batangas, Rizal, and Quezon, for the Philippines; the Greater Bangkok area for Thailand; and the Hanoi 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. 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: Establishment Survey on Innovation and Production Network.

Let us take a brief look at a firm's choice of transportation mode. Table A1 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 those 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 A2 shows the transportation mode by the location of firms, indicating that most of our sample firms tend to choose truck transportation. Intuitively, this may be consistent with the first fact that most of the firms trade domestically.

Table A2. Chosen Transportation Mode by Location of the Firms

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

Source: Establishment Survey on Innovation and Production Network.

The MNL result is provided in Table A3. 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 for air and sea than for truck. Third, the intercept term of distance in machinery industries has a significantly positive coefficient for air. This result may indicate large time costs in the machinery industry.

Table A3. Multinomial Logit Analysis Results

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 for 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 transportation. In the calculation, we set Abroad to the value of one, i.e. international transactions. The results are reported in Table A4. 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 truck transportation.

Table A4. Probability-Equivalent Distance with Truck Transportation (Kilometres): 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 results in Table A3.

We estimate some parameters necessary for calculating the transport costs. Specifically, we estimate transportation speed and holding time. Our strategy for estimating these is 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 A5. 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. As for the distance coefficient, its magnitude for sea and truck transportation is reasonable, but that for 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 the land transportation time to the airport. This causes the air transportation speed to be understated.

Table A5. OLS Regression Results: 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 (Kilometres/Hour)	55.556	14.706	38.462
Observations	51	34	754
R-squared	0.1225	0.3698	0.1772

Notes: ***, **, and * show 1%, 5%, and 10% significance, respectively. The 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 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 industry *s* by mode *M* between regions *i* and *j* is assumed to be expressed as:

$$C_{ij}^{s,M} = \underbrace{\left[\left(\frac{dist_{ij}}{Speed_M}\right) + \left(1 - Abroad_{ij}\right) \times ttrans_M^{Dom} + Abroad_{ij} \times ttrans_M^{Intl}\right]}_{Total\ Transport\ Time} \times ctime_s + \underbrace{dist_{ij} \times cdist_M}_{Physical\ Transport\ Cost} + \underbrace{\left(1 - Abroad_{ij}\right) \times ctrans_M^{Dom} + Abroad_{ij} \times ctrans_M^{Intl}}_{Physical\ Transshipment\ Cost} \quad (2)$$

where $dist_{ij}$ is the travel distance between regions *i* and *j*, $speed_M$ is the travel speed per one hour by mode *M*, $cdist_M$ is the physical travel cost per one kilometre by mode *M*, and $ctime_s$ is the 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 the estimation and borrowing some parameters from the ASEAN Logistics Network Map in JETRO (2008), we set some of the parameters in the transport function as in Table A6. Notice that our estimates of $Speed_{\mathrm{Air}}$ and $ttrans_{\mathrm{Air}}^{Intl}$ in Table A6 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 the JETRO (2008).

Secondly, after substituting those parameters for 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 and 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 the border costs and transshipment costs in international transport from Bangkok to Hanoi. The parameters $sttrans_M^{Dom}$ 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 ASEAN Logistics Network Map 2008.

- The transport cost using trucks becomes the lowest among 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 A4, 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	1803.3	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 among 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	1380.1

Source: Authors' calculation.

Additionally, $ttrans^{Dom}$ and the railway speed are estimated by the same dataset and the same estimating equation. Due to the minimal use of railways in international transactions in the dataset, we adopt 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.[e]

[e] The ASEAN Logistics Network Map 2008 offers an example where the cost per kilometre for railway 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. Railways have much larger economies of scale than trucks in terms of shipping volume, so some industries, such as coal haulage, incur much lower costs per ton-kilometre. Therefore, we need to deduct this from the value in the ASEAN Logistics Network Map 2008.

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 non-tariff barriers (TNTB) by countries 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 (not each subnational region). This approach looks more appropriate than other approaches because the theoretical model underlying this approach is basically the same as our GSM. We estimate the ratio of the 'consumption of products from country *j* in country *i* (X_{ij})' to the '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.

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 the circular constant and surface area, respectively. *Cost* is the sum of the physical transport costs and time costs, for which the computation has been explained. Last, the 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 the 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 while 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 Indicators (World Bank). Those on geographical distance and three dummy variables on preferences are from CEPII database. With this methodology, we estimate the industry-level fixed effects for 69 countries.

The estimation results by the ordinary least square (OLS) method are reported in Table A10. 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 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.

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

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

Notes: *** and ** indicate 1% and 5% significance, respectively. Robust standard errors are in parentheses. All specifications include import country dummy variables.
Source: Authors' calculation.

Next, we obtain the NTBs by subtracting tariff rates from the TNTB. Our data source for the tariff rates is the World Integrated Trade Solution, particularly Trade Analysis and Information System (TRAINS) raw data. For each trading pair, we aggregate the lowest tariff rates among all available tariff schemes at the tariff-line level into single tariff rates for each industry by taking a simple average. The available tariff schemes include multilateral free trade agreements (FTAs) (e.g. ASEAN+1 FTAs) and bilateral FTAs (e.g. the China–Singapore FTA) alongside other schemes, such as the Generalized System of Preferences. Moreover, we somewhat take into account 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 among member countries began to gradually decline from 2008. The tariff rates in Japan and the ASEAN forerunners against members are, for simplicity, assumed to linearly decrease to become the final rates in 2018, and those for the ASEAN latecomers decrease linearly to the final rates in 2026.[f] 'Final rates' takes into account the final rates set in each agreement; namely, even if the 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 by ERIA. We set the 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 the (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 for the 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 AJCEP is estimated at around 3%. Based on this estimate, we formalise the effect of the diagonal cumulation rule among ASEAN+1 FTAs as 3% below NTBs in trading among 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 the importer's GDP, exporter's GDP, importer's corporate tax,

[f] We do not insert the exact schedule of the gradual tariff reductions due to the lack of ready-made information. The ASEAN forerunners are Brunei Darussalam, Indonesia, Malaysia, the Philippines, Singapore, and Thailand. The latecomers are Cambodia, the Lao PDR, Myanmar, and Viet Nam.

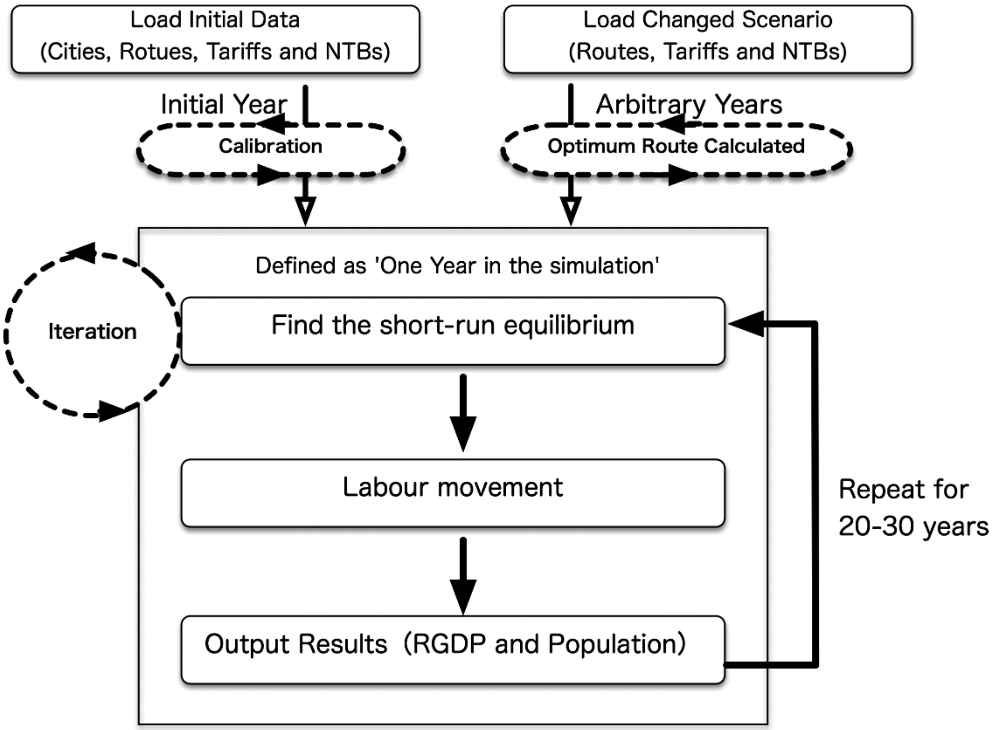
geographical distance between countries, a dummy for FTAs, a linguistic commonality dummy, and a colonial dummy. The elasticity for services is obtained from the transformation of a coefficient for the corporate tax because it changes the prices of services directly. For this estimation, we mainly employ 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 we cannot do so because we lack sufficiently reliable consumption data. 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 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 2005 by IDE and *Zai-Asia Oceania Nikkei Kigyo Jitta Chosa 2013* by JETRO. 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.

Simulation Procedure

This sub-section explains our simulation procedure, which are depicted in Figure A2. First, with the given distributions of employment and regional GDP by sector and region, the short-run equilibrium is obtained. The equilibrium nominal wages, price indices, output, and GDP by region are calculated.

Figure A2. Simulation Procedure



Source: Authors.

Observing the achieved equilibrium, workers migrate among 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.

Calculation of the Economic Impacts

To calculate the economic impacts of specific trade and transport facilitation measures (TTFMs), we take the differences of the RGDPs 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 RGDPs between two scenarios typically in 2030. If the RGDP 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 impact of the TTFMs.

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

Making the Scenarios

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 (TNTBs) are changing based on the 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 the 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
- 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 the year 2023, we gradually reduce the calibrated growth rates of the technological parameters to half in 20 years.

In the baseline scenario, transport settings are unchanged throughout the simulation period 2010–2030, 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. The average air traffic speed is set at 800 km/h between the primary airports of each country and at 400 km/h on other routes. The average railway traffic speed is set at 19.1 km/h.

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 also reduction of the NTBs taking into account the 'cumulation' effect of an FTA/RTA
- Overall improvements in business environments: reduction of NTBs for a country

Special Economic Zones (SEZs) and Free Trade Zones (FTZs)

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 SEZs/FTZs.

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