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## IDE DISCUSSION PAPER No. 774

### **(Re)defining Economic Corridors**

Ikumo ISONO<sup>†</sup> and Satoru Kumagai<sup>‡</sup>  
March 2020

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Economic corridors connect production bases, markets, and gateway ports to the outside region, thereby stimulating economic integration and development in remote areas. In terms of recognition, development programmes, and effectiveness, economic corridors in the Greater Mekong Subregion (GMS) are one of the region's best practices. Several other regions have adopted similar approaches. However, one major problem concerning economic corridors is that the selection of economic corridors is inconsistent from an economic perspective. This paper uses the Geographical Simulation Model developed by the Institute of Developing Economies. As an experimental study, this paper redefines economic corridors in the GMS from an economic perspective and discusses the favourable conditions for economic corridors.

**Keywords:** Economic corridors, Simulation, Greater Mekong Subregion

**JEL classification:** O18, R12, R58

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# (Re)defining economic corridors

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## Abstract

Economic corridors connect production bases, markets, and gateway ports to the outside region, thereby stimulating economic integration and development in remote areas. In terms of recognition, development programmes, and effectiveness, economic corridors in the Greater Mekong Subregion (GMS) are one of the region's best practices. Several other regions have adopted similar approaches. However, one major problem concerning economic corridors is that the selection of economic corridors is inconsistent from an economic perspective. This paper uses the Geographical Simulation Model developed by the Institute of Developing Economies. As an experimental study, this paper redefines economic corridors in the GMS from an economic perspective and discusses the favourable conditions for economic corridors.

## Introduction

In terms of recognition, development programmes, and effectiveness, economic corridors in the Greater Mekong Subregion (GMS) are one of the region's best practices. Several regions have begun adopting the economic corridor approach considering its success in the GMS.

Economic corridors connect production bases, markets, and gateway ports with the outside region, stimulating economic integration and development in remote areas (Ishida and Isono 2012, Banomyong 2008). Economic corridors in the Mekong region have expanded production networks in Southeast and East Asia. Since the mid-1980s, East Asian countries have attracted multinational enterprises, mainly in the manufacturing sector, promoted industrialisation, and expanded trade, especially in intermediate goods, thereby contributing to economic development. However, one major challenge was that the provision of infrastructure and good regulations for the production activities of multinational enterprises was limited to large economic cities, gateway ports, and gateway airports in each country. Moreover, trade was supported by maritime and air transport. Furthermore, intraregional land transport has remained expensive owing to poor infrastructure, lack of institutions, additional costs such as unnecessary checkpoints and theft, and lack of competition among logistics companies. Consistent with the policy objectives, the economic corridor approach has extended the benefits of the largest

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economic city to the regions along the corridors by connecting production bases, markets, and gateway ports in the Mekong region. Furthermore, this approach has facilitated the needs of multinational enterprises that have been moving labour-intensive production processes into low-wage regions.

However, the economic corridor approach adopted in the GMS has received academic criticisms. One such criticism is that the designation of economic corridors is not from an economic perspective and therefore deviates from actual and commonly used transport routes (Banomyong and Sopadang 2009). This paper uses the Institute of Developing Economies-Geographical Simulation Model (IDE-GSM, Kumagai et al. 2013) to conduct an experimental study of economic corridors. Considering the Mekong region as an example, this paper discusses the favourable conditions for adoption of economic corridors in other regions. Kumagai, et al. (2019) examined the validity of the road corridor in South Asia Subregional Economic Cooperation by comparing their findings with the simulation results of the IDE-GSM. Although several road corridors are consistent with the high-traffic roads in the simulation results, some road corridors have low traffic. In some cases, (1) road corridors are not the shortest route connecting large economic cities; (2) another large economic city exists near the route, although it was the shortest route connecting large economic cities and it was chosen to go through that city in the simulation; and (3) trade was impeded by border barriers, decreasing the transport volume. In the first and second cases, a problem exists in defining the economic corridors. In the third case, the designation of corridors is not effective due to a lack of policy, although designation itself should have been reasonable. This study focuses on the Mekong region and uses the IDE-GSM simulation results to reconfigure economic corridors. The Economic Research Institute for ASEAN and East Asia (ERIA, 2015) stated that new economic corridors may emerge due to the appropriate implementation of infrastructure projects. Furthermore, this paper argues that new transport patterns may be generated through expected future infrastructure projects and that economic corridors could be defined according to new transport patterns.

The conclusions are as follows. The economic corridors redefined from the simulation results of the IDE-GSM are almost consistent with the efforts of past corridors and highways; however, in some cases, new corridors can be seen or the corridors of past efforts cannot be seen. For the former, policies to revitalise the new economic corridors are urgently required. The latter is less essential from an economic perspective and more crucial from a political perspective. Therefore, reconsidering whether the economic corridor approach is appropriate in the areas that deviate from the simulation results is necessary.

The structure of this paper is as follows. Section 2 presents the definition of economic corridors and describes its adoption in the Mekong region. It compares other corridor and highway initiatives. Section 3 outlines ways in which IDE-GSM calculates the transport volume, runs simulations, and defines the economic corridors in the Mekong region based on the simulation results. Section 4 concludes the paper by discussing the ideal form of

economic corridors.

## **2. Economic corridors, corridors, and highways**

### **2.1. Definition of economic corridor**

According to the Asian Development Bank (ADB)<sup>2</sup>, economic corridors have the following characteristics:

- It covers smaller, defined geographic spaces, usually straddling a transport artery such as a road, rail, or canal.
- It emphasises bilateral rather than multilateral initiatives, focusing on strategic nodes at border crossings between two countries.
- It highlights physical planning of the corridor to focus on infrastructure development and achieve positive benefits.

These characteristics were intended to give priority to bilateral cooperation and hard infrastructure in line with the situation in the Mekong region at the time. Furthermore, economic corridors are integrated systems of roads, railways, and ports that connect the borders of GMS countries, production bases, markets, and regional and international trade gateways (ADB 2016). According to ERIA (2010), ‘The term “economic corridor” refers to roads, bridges, and other transport infrastructure that pass through several countries, enabling the active movement of people and products across national borders’. Economic corridors span multiple countries.

Economic corridors do not simply connect already developed production bases and markets. It aims to spread the benefits of economic integration and development to other regions and inland regions. Ishida and Isono (2012) stated that ‘the economic corridor is expected not only to connect the centres of economic activities but also to extend the benefits from developing transport projects to remote rural areas’. According to Banomyong (2008), ‘the economic corridor... is able to attract investment and generate economic activities along the less developed area or region’.

It met the policy requirement to expand the benefits of economic integration and development to other regions. The development of the production network, especially in Association of Southeast Asian Nations (ASEAN), was limited to the area from the largest economic city to the gateway port of each country. As stated by Brunner (2013), ‘Economic corridors connect economic agents among a defined geography. They provide connection between economic nodes or hubs. They link the supply and demand sides of markets. Economic corridors... have to be analysed as part of integrated economic networks, such as global and regional value chains and production networks’.

Brunner (2013) identified four policy issues related to the economic corridor in Asia

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<sup>2</sup> Retrieved from Web archive.

based on the view that economic corridors further expand production networks and promote economic integration:

- Bridging a divided geography
- Development of regional markets
- Balancing growth and income distribution (geographically)
- Building up resilience to interruptions of movement of economic resources

The discussion of economic corridors calls for a shift from transport corridors to economic corridors. Perdiguero (2016) distinguished five steps in the development of economic corridors:

- The first step is transport corridor through the development of physical infrastructure
- The second step is trade facilitation corridor, with cross-border transport operations and efficient border formalities
- The third step is the logistics corridor, with broader trade facilitation (behind-the-border) and developed cross-border logistics services
- Fourth is the urban development corridor, with improved economic infrastructure and enhanced capabilities of corridor towns for public–private partnerships
- Fifth is the economic corridor, with increased private investment and well-developed production chains

According to Banomyong (2008),

1. Transport corridor physically links an area or region.
2. Multimodal corridor physically links an area or region through the integration of various modes of transport.
3. Logistics corridor not only physically links an area or a region but also harmonises the corridor institutional framework to facilitate the effective movement and storage of freight, people, and related information.
4. Economic corridor attracts investment and generates economic activities along the less developed area or region. Physical linkages and logistics justification must be in place in the corridor as a prerequisite.

Economic corridors should function as part of the production network. Furthermore, ADB views the economic corridor approach as an informative mechanism for advancing regional economic cooperation. Among these, formal mechanisms include free trade areas, customer union, and common market frameworks, whereas growth triangles and translational free zones are listed as informal mechanisms.

Economic corridors mean prioritising regional development (ADB 2016). Highlighting the existence of economic corridors, ADB aims to create demonstration

effects by focusing on infrastructure and industry investments along the corridors by ADB, donor countries, and international organisations as well as by focusing on development and resulting economic development as successful examples.

## **2.2.GMS economic corridor and its evaluation**

The GMS economic corridor can be divided into three stages (ADB 2016). Stage 1, from 1992 to 1997, provided the basis for corridor development and identified priority road projects. The final report on the subregional transport sector study for the GMS was approved in the fourth GMS ministerial conference held at Chiang Mai, Thailand, in 1994. Nine priority road projects were identified in this study.

- R1 Bangkok-Phnom Penh-Ho Chi Minh City-Vung Tau Road Project
- R2 Thailand-Lao PDR-Vietnam East–West Corridor Project
- R3 Chiang Rai-Kunming Road Improvement Project via Myanmar and Lao PDR
- R4 Kunming-Lashio Road Improvement Project
- R5 Kunming-Hanoi Road Improvement Project
- R6 Southern Lao PDR-Sihanoukville Road Improvement Project
- R7 Lashio-Loilem-Kengtung Road Improvement Project
- R8 Southern Yunnan Province-Northern Project Thailand-Northern Lao PDR-Northern Vietnam Road Improvement Project
- R9 Northeastern Thailand-Southern Lao PDR-Northeastern Cambodia-Central Vietnam Corridor Project

The second stage, from 1998 to 2007, began with the adoption of the economic corridor approach. At the 8th GMS Ministerial Conference in Manila in 1998, nine priority road projects were incorporated into economic corridor concepts that identified the North–South Economic Corridor (NSEC), East–West Economic Corridor (EWEC), and Southern Economic Corridor (SEC).

### **North-South Economic Corridor**

- Kunming–Bangkok
- Kunming–Hanoi–Haiphong

### **East-West Economic Corridor**

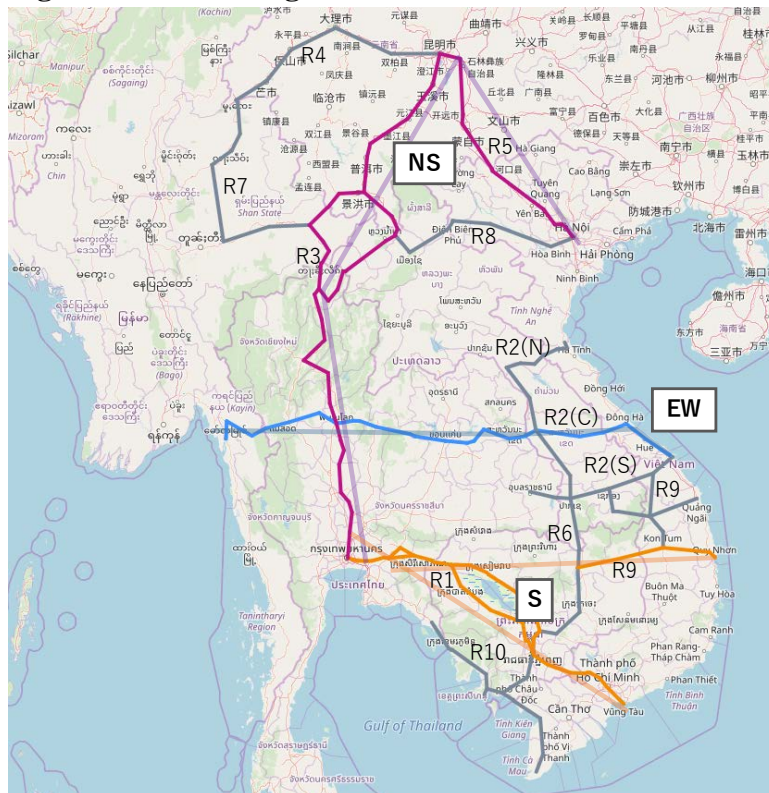
- Mawlamyine-Da Nang

### **Southern Economic Corridor**

- Bangkok–Phnom Penh–Ho Chi Minh City–Vung Tau
- Bangkok–Siem Reap–Stung Treng–Pleiku–Quy Nhon

With respect to the NSEC, the new routes between Hanoi and Nanning as well as between Kunming and Nanning were added in 2004.

**Figure 1: GMS's original three economic corridors**



Source: Compiled by authors based on ADB (2002). Background map is provided by OpenStreetMap under the Creative Commons Attribution-ShareAlike 2.0 license (CC BY-SA).

These three economic corridors were widely recognised by the region. Infrastructure investment was particularly concentrated in the EWEC. Notably, the Second Thai–Lao Friendship Bridge over the Mekong connected Mukdahan Province with Savannakhet in 2005. It was financed by Japan’s Official Development Assistance, an example of how donor countries and donor organisations have responded to ADB’s economic corridor by focusing on infrastructure investments along the EWEC.

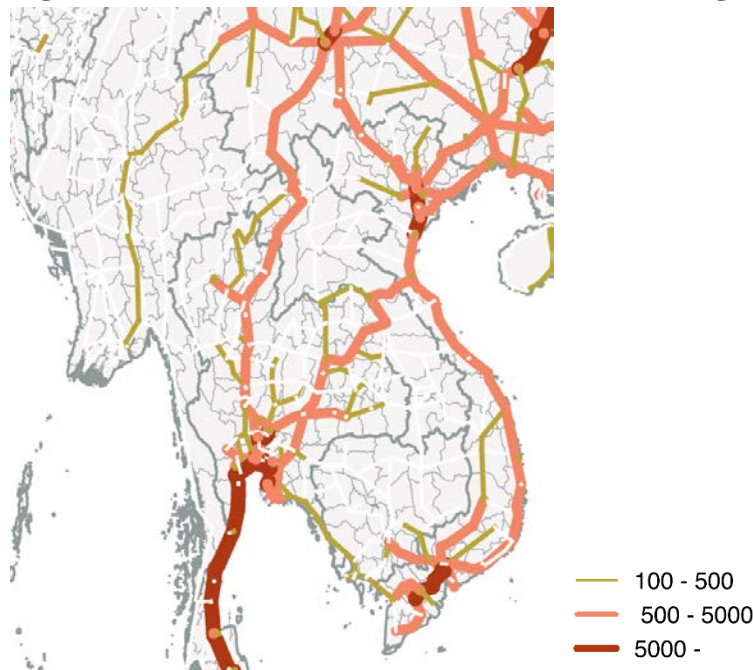
The development along the EWEC continued. In 2015, a bypass between Myawaddy and Kawkaileik was completed, eliminating the harsh one-day one-sided driving environment. Stakeholder recognition of the EWEC can be observed in a news release about Toyota Boshoku’s penetration into Savannakhet. When they announced the commencement of manufacturing automobile seat covers, the release stated that ‘As a member nation of the East-West Economic Corridor, Laos is advantageous for distribution to Thailand and has stable electricity supply and other infrastructure’.

Furthermore, the economic corridor approach, particularly the EWEC, has been criticised. One major criticism is that economic corridors are located far from the actual transportation routes, implying that they are not defined from an economic perspective. Banomyong and Sopadang (2009) indicated that the EWEC region of Thailand cannot be



a crucial transport route as the actual route is from Bangkok to Tak and from Bangkok to Hanoi and Ho Chi Minh City via Mukdahan–Savannakhet and Densavanh–Lao Bao borders. Figure 2 depicts land transport for international intermediate trade in 2015 in the IDE-GSM simulation. The figure indicates a high traffic volume on the road extending from Bangkok to the surrounding areas and a low traffic volume along the EWEC.

**Figure 2: International transaction of intermediate goods (2015)**



Source: IDE-GSM simulation result

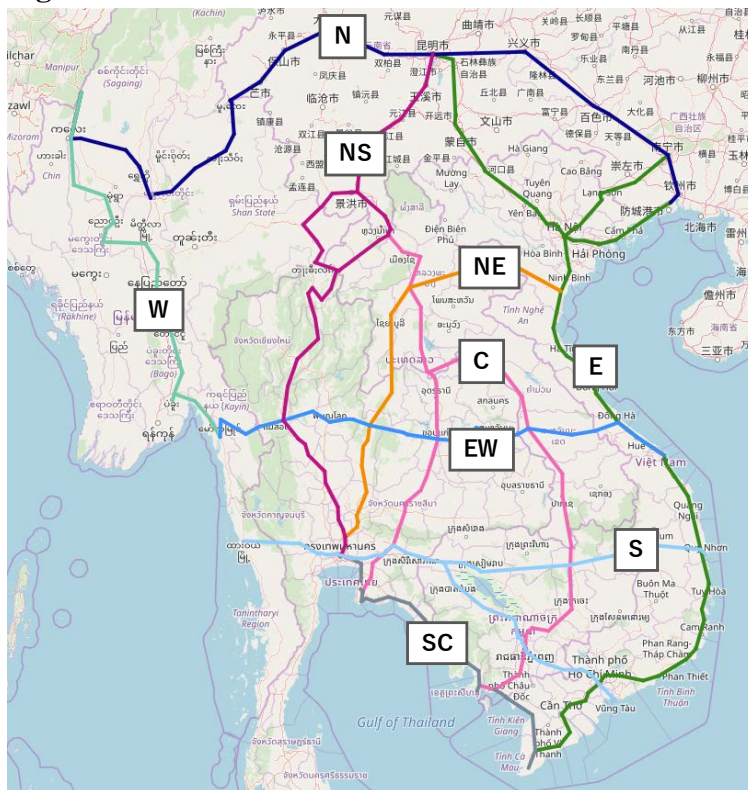
According to Perdiguero (2016), the EWEC is not yet an economic corridor. Mae Sot, Hpa An, and Savannakhet have witnessed the entry of firms into the production network. However, these have not resulted from the investment linkage along the EWEC but from the linkages around Bangkok and Mae Sot, around Bangkok and Hpa An, and around Bangkok and Savannakhet, which are far from the original purpose of the economic corridor.

Moreover, ADB has not always been successful in promoting economic corridors. Although the definition of economic corridors in the GMS has changed, the recognition of stakeholders has not progressed.

The third stage, from 2008, began with the formulation of strategies and action plans for the three corridors. In 2006, the GMS Transport Sector Strategy (TSS) for 2006–2015 was endorsed, and nine corridors constituting the GMS corridor network were identified. The three existing economic corridors became part of this corridor network and were designated as priority corridors for the transition from transport corridor to economic corridors.

- i. North–South Corridor (NSC): Kunming to Bangkok
- ii. Eastern Corridor (EC): Kunming to Ca Mau
- iii. East–West Corridor (EWC): Mawlamyine to Da Nang
- iv. Southern Corridor (SC): Dawei to Quy Nhon/Vung Tau
- v. Southern Coastal Corridor (SCC): Bangkok to Nam Can
- vi. Central Corridor (CC): Kunming to Sihanoukville/Sattahip
- vii. Northern Corridor (NC): Fangcheng to Tamu
- viii. Western Corridor (WC): Tamu to Mawlamyine
- ix. Northeastern Corridor (NEC): Thanh Hoa to Bangkok/Laem Chabang

**Figure 3: GMS TSS corridors**



Source: Compiled by authors based on ADB (2016). Background map is provided by OpenStreetMap under the Creative Commons Attribution-ShareAlike 2.0 license (CC BY-SA).

With the TSS, the NSEC and SEC were expanded as indicated in Figure 4 (ADB 2016).

#### NSEC

- Kunming–Chiang Rai–Bangkok via the Lao PDR or Myanmar (Western Subcorridor)
- Kunming–Hanoi–Haiphong (Central Subcorridor)

- Nanning–Hanoi via Pingxiang in the PRC and Dong Dang in Viet Nam, or via Fangcheng and Dongxing in the PRC and Mon Cai in Viet Nam (Eastern Subcorridor)

## SEC

- Bangkok–Phnom Penh–Ho Chi Minh City–Vung Tau (Central Subcorridor)
- Bangkok–Siem Reap–Stung Treng–Ratanakiri–O Yadav–Pleiku–Quy Nhon (Northern Subcorridor)
- Bangkok–Trat–Koh Kong–Kamport–Ha Tien–Ca Mau City–Nam Can (Southern Coastal Subcorridor)
- Sihanoukville–Phnom Penh–Kratie–Stung Treng–Dong Kralor (Tra Pang Kriel)–Pakse–Savannakhet (Intercorridor Link, which connects the three SEC subcorridors with EWEC)

**Figure 4: GMS economic corridors under TSS**



Source: Compiled by authors based on ADB (2016). Background map is provided by OpenStreetMap under the Creative Commons Attribution-ShareAlike 2.0 license (CC BY-SA).

In addition, the further expansion of economic corridors was recommended to address the following issues, and the GMS Ministers endorsed the recommendations of the study at the 21st GMS Ministerial Conference in Thailand in 2016.

- There is relatively limited coverage of the Lao People's Democratic Republic (Lao PDR) and Myanmar in the economic corridors.
- Yangon, Nay Pyi Taw, and Vientiane are not included in any economic corridor.
- Yangon Port is not linked to any economic corridor.
- The principal cross-border trade routes between the People's Republic of China (PRC) and Myanmar; Myanmar and Thailand; and the PRC, the Lao PDR, and Thailand are not reflected in the alignment of the economic corridors.

**Figure 5: GMS's new three economic corridors**



Source: Compiled by authors based on ADB (2016). Background map is provided by OpenStreetMap under the Creative Commons Attribution-ShareAlike 2.0 license (CC BY-SA).

These extensions are not well recognised by stakeholders. In addition, the NSEC and SEC included almost all major highways, leading to further challenges. While the original economic corridor approach prioritised development, no prioritisation was provided here.

### 2.3. Other initiatives

Several other initiatives exist in the Mekong region to name roads. The Asian/ASEAN Highway and the Trilateral Highway are outlined, and their characteristics are described.



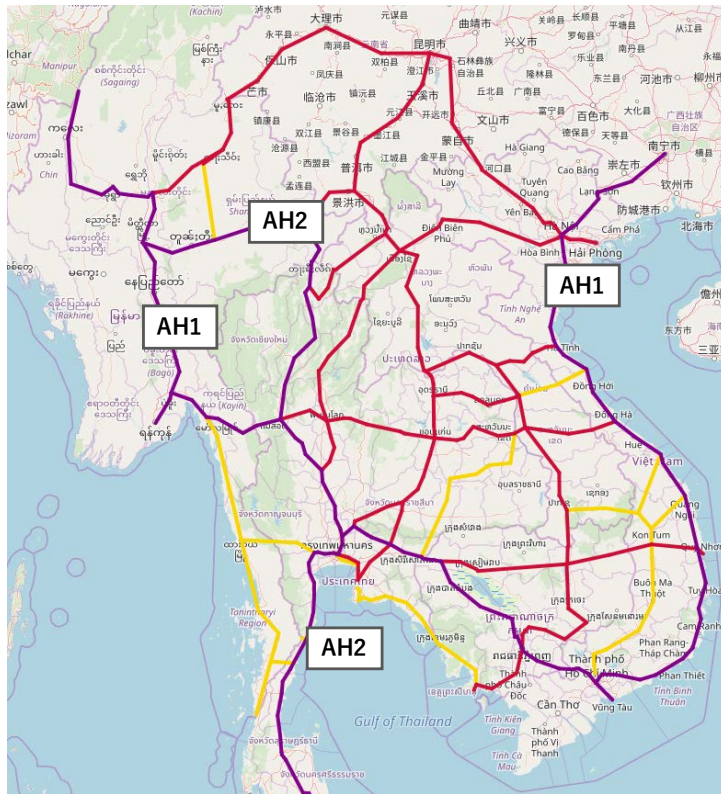
### **2.3.1. Asian Highway/ASEAN Highway**

The institutional backbone for the development of transport networks in the Economic and Social Commission for Asia and the Pacific (ESCAP) region is the Intergovernmental Agreement on the Asian Highway Network, entered into force in July 2005. As of June 2019, the network covered more than 143,000 km in East, Northeast, North and Central Asia, Southeast Asia, and South and Southwest Asia (ESCAP 2019).

The ASEAN Highway Network (AHN) is an expansion within ASEAN of the Trans-Asian Highway Network, spanning a length of 38,400 km and covering 23 designated routes. Across ASEAN, 120,000 km of roads have been built and improved.

These highways are similar to ADB's economic corridors and TSS corridors, with different naming characteristics. The major difference is that each highway does not have a view of connecting major economic cities and ports. Accordingly, it is close to the priority road projects for which ADB's final report was approved in 1994. The ASEAN Highway is designated as an addition to the Asian Highway, and the Master Plan on ASEAN Connectivity prioritises the development of those highways additionally designated, thereby reducing their economic importance (ASEAN 2011, Iso and Kumagai 2016).

**Figure 6: Asian/ASEAN Highways**



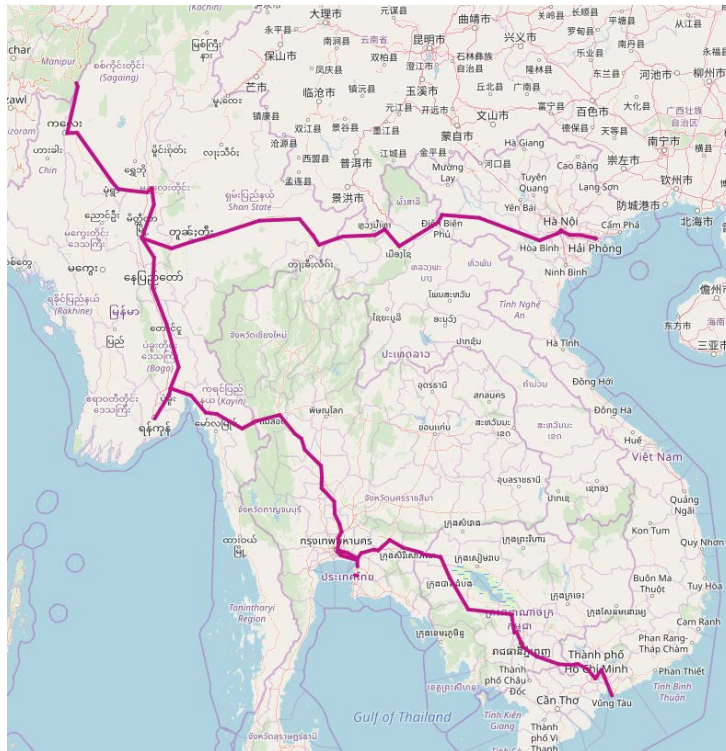
Source: Compiled by authors based on UNESCAP and ASEAN websites. Background map is provided by OpenStreetMap under the Creative Commons Attribution-ShareAlike 2.0 license (CC BY-SA).

### 2.3.2. Trilateral Highway

The 1360-km long India–Myanmar–Thailand Trilateral Highway links India, Myanmar, and Thailand. The Trilateral Highway passes through the Asian Highway No. 1 route between Myanmar and Thailand, with extension to Cambodia and Vietnam<sup>3</sup>. Umezaki's (2020) analysis included a route from Naypyitaw to Hai Phong. In this analysis, large economic cities are connected with the gateway port, and the connection to the Laem Chabang Port has been added to the analysis.

<sup>3</sup> Kale–Mandalay section in Myanmar differs from AH1.

**Figure 7: Trilateral Highway**



Source: Compiled by authors based on the study by Kumagai and Umezaki (2020). Background map is provided by OpenStreetMap under the Creative Commons Attribution-ShareAlike 2.0 license (CC BY-SA).

### 3. Redefining economic corridors using IDE-GSM

#### 3.1. Observations through IDE-GSM and selection of roads

We used the transport volume of the simulation result of IDE-GSM to define an economic corridor. First, we outlined the way in which the transport volume is determined by IDE-GSM. See Appendix 1 for a detailed calculation of transport costs. IDE-GSM includes land transportation (trucks), railways, marine transportation, and air transportation. Transport costs include monetary transport costs, time costs, tariffs, and non-tariff barriers<sup>4</sup>. Monetary transport costs are a function of the distance travelled by mode, the monetary transport costs per km<sup>5</sup>, and the additional administrative costs at borders, stations, ports, airports, and so on. The cost of transport from the point of origin to the destination shall be the total time of transport multiplied by the time cost plus the cost of financial transport.

The firms in the model first select the modes of transport and the route to be taken in

<sup>4</sup> It is not assumed that trucks carrying precision machinery will choose a flatter, less rough road.

<sup>5</sup> It is assumed that the cost per km does not change even if it is one-way trade/transport.

each mode of transport to minimise the cost of transport from the origin to the destination. Considering the time cost, firms will choose a faster route if the monetary cost of transport is the same per kilometre. Time costs vary by industry. Time-intensive industries choose routes that enable them to ship faster, even if the monetary cost of transport is high. Industries with lower time costs choose routes that minimise their monetary transport costs. Thus, for each industry and each origin/destination pair, the route chosen by the firm may vary. First mode is land transportation from the point of departure, unless the destination is adjacent to a port, airport, or railway station. Transshipment requires additional time and expense.

The IDE-GSM transport model is built to reflect the characteristics obtained from ERIA's Establishment Survey on Innovation and Production Network project. The model has the following features. For domestic transport, firms use land transport as much as possible. For international transportation, firms choose marine and air transportation. The electric and electronic industry, which has high time costs, chooses air transport more. Other industries such as manufacturing and agriculture more likely choose maritime shipping. The mode of transport actually chosen may vary depending on the geographical structure. If land transport is unavailable for domestic transportation because the islands are separated, marine transport or air transport is used. Land-based transport is preferred for international transport if ports and airports are remote, destination is relatively close by land transport, roads are of good quality, or the time and cost at land borders are relatively low.

When considering economic corridors primarily for land transport, conditions may favour the frequent use of one route. First, several large economic cities exist along a route in a country. Firms use land transportation as much as possible for domestic transportation; thus, routes between large economic cities are frequently used. Second, maritime shipping is a long way round and consumes a great deal of time and money. Land transport may be preferred to maritime shipping when the former mode is faster. Third, the distance between economic cities is short even in the case of international transportation. Similarly, in some cases, land transport is desirable than transshipment by sea or air considering time and costs. Fourth, the quality of the roads is good, and the time and costs at the border are relatively low. The lower the time and cost at the land border, the lower the total transport cost and higher the use of land transport.

Further, the volume of international transport depends on the size of tariffs and non-tariff barriers. With liberalisation and institutional economic integration, average tariff rates and tariff-equivalent non-tariff barriers decline and the volume of international transport rises. In addition, with the expansion of the size of each country's economy, the volume of goods transported through international transport increases as companies sell or purchase more goods from overseas.

This paper simulates infrastructure projects developed up to 2020 and assumes infrastructure projects to be completed between 2021 and 2025. As new ports and highways are completed, the routes chosen by companies may vary from the current



condition of the infrastructure.

IDE-GSM allows households and firms to move within the country. Households move to areas where real wages are higher. The numbers of firms in each region change as households move. An attractive city draws many households and firms, resulting in increased traffic to and from the city. When a new infrastructure project is developed, the cities near the infrastructure project have a relative advantage. In this case, households and firms will move to cities near the project, thereby increasing the volume of traffic that arrives and departs.

We redefined an economic corridor through IDE-GSM simulation. A simulation will be conducted until 2035 to examine the volume of land transport. This section describes the volume of land transportation of intermediate goods in international trade and defines the route with a large volume of land transportation in the Mekong region as a potential economic corridor. As discussed in Section 2, Perdiguero (2016) and Banomyong (2008) defined economic corridors as areas along which private investment increases and those that function as part of production networks. IDE-GSM does not address factors such as investment or foreign direct investment. Intermediate goods trade has been considered to be an indicator of the development of production networks because it may occur within the same business group and because it requires appropriate information management between business groups. In addition, the expansion of production networks has already progressed to international land transport, such as land trade between Bangkok and Hanoi and intermediate goods trade between Bangkok and Savannakhet in Laos. Accordingly, intermediate goods trade can be effectively used as an indicator.

This paper assumes that an infrastructure project will be completed between 2021 and 2025 and performs simulations. The following hard and soft infrastructure projects are assumed to be developed between 2021 and 2025 (Partially revised from ERIA 2015).

- Improve major roads in Myanmar
- Open the Dawei Port in Myanmar with regional feeder shipping routes to Kolkata, Vishakhapatnam, Chennai, and Colombo
- Open Myanmar's Kyaukphyu port with regional feeder lines to Kolkata, Vishakhapatnam, Chennai, Colombo, and Singapore
- Improve the road between Dawei in Myanmar and Kanchanaburi in Thailand
- Improve the road from Siem Reap in Cambodia to Qui Nhon in Vietnam
- Improve Cambodia's Phnom Penh Sihanoukville Expressway
- Improve Laos' national roads 13(N), 8, and 12
- Complete Vietnam's North-South Highway
- Customs clearance to be facilitated at the following land borders:
  - Kanchanburi-Dawei
  - Myawaddy-Mae Sot
  - Moreh-Tamu
  - Ruili-Muse

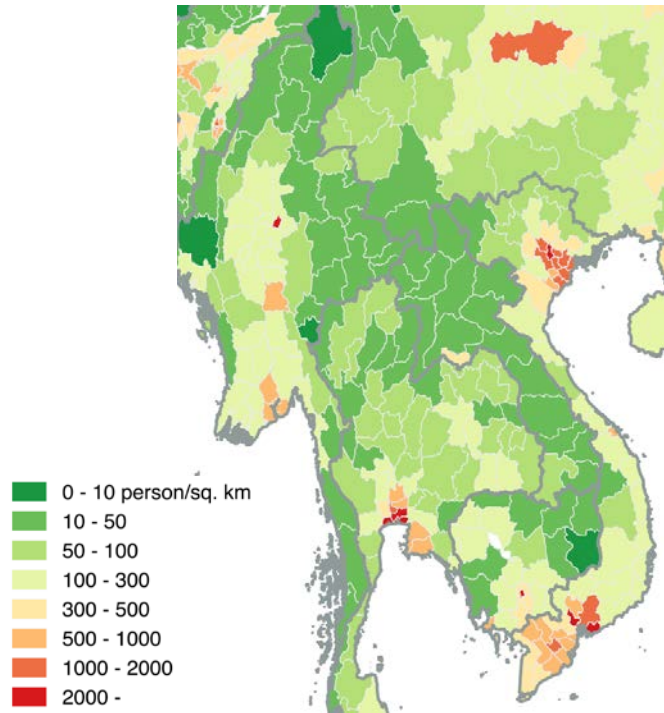
- Tachileik-Mae Sai
- Mong La-Daluo
- Savannakhet -Mukdahan
- Densavanh-Lao Bao
- Hekou-Lao Cai
- Poipet- Aranyaprathet
- Bavet-Moc Bai
- Lok-Xa Xia
- Kaoh Kong- Khlong Yai
- Trapeangkreal-Khinak
- Oyadav-Le Thanh
- Vientiane-Nong Khai-
- Namsouy-Nameo
- Houayxay-Chiang Khong
- Mohan-Boten
- Youyiguan-Dong Dang
- Nam Phao-Cau Treo
- Na Phao-Cha Lo
- Laos-Viet Nam border at Vientiane-Vinh Expressway

### **3.2. Economic conditions in the Mekong region**

Before examining the volume of transport, we consider the economic situation in the Mekong region, especially in 2035, the year when the simulation ends.

Figure 8 presents the population density in 2035. The most densely populated areas in the Mekong region are Bangkok and the Eastern Economic Corridor Area of Thailand, Ho Chi Minh City area and southern Vietnam, near Hanoi, Yangon, Nay Pyi Taw, and Mandalay in Myanmar, and Phnom Penh and Vientiane. Most parts of Laos, northern Cambodia, and north-eastern Myanmar have low population densities that put them at a disadvantage for economic activity.

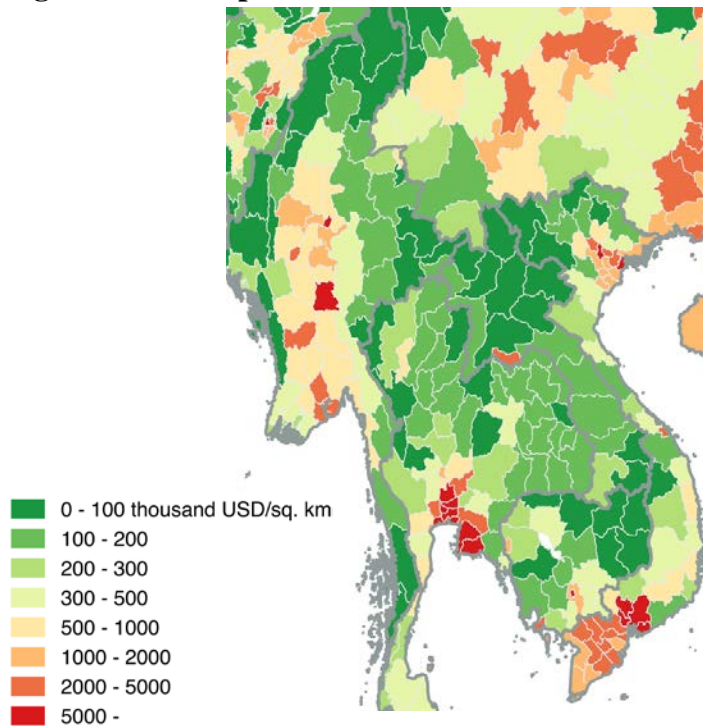
**Figure 8: Population density (2035)**



Source: IDE-GSM simulation result.

Figure 9 presents the gross regional domestic product (GRDP) per area. The GRDP makes it difficult to know the regions in which economic activities are actually concentrated. This is because the GRDP is large in large areas and small in small areas. Furthermore, the GRDP per area indicates the accumulation of economic activities across multiple prefectures. Similar to the population density, economic activities are concentrated around Bangkok, the Eastern Economic Corridor Area of Thailand, southern Vietnam, and Hanoi. Large and relatively large economic activities exist in the area connecting Yangon–Mandalay in Myanmar. In addition to the accumulation of economic activities in Kunming, many regions in China have relatively high economic activities, reflecting China's high economic growth forecast.

**Figure 9: GRDP per area**



Source: IDE-GSM simulation result.

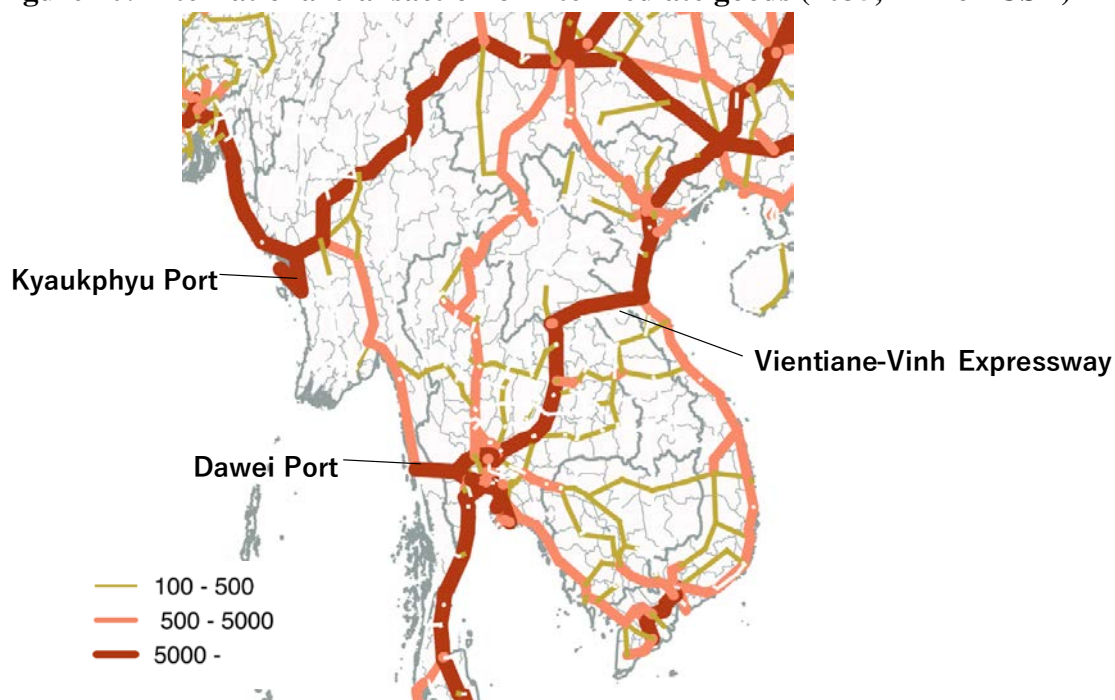
The following additional indicators are presented in Appendix 2.

- Population changes (2015–2030)
- GRDP (2035)

### **3.3. Indicator of traffic volume**

Figure 10 presents the land transport volume of international intermediate goods trade in 2035. This includes land transportation to ports and airports for export to or import from foreign countries and excludes domestic transactions.

**Figure 10: International transaction of intermediate goods (2035, Million USD)**



Source: IDE-GSM simulation result.

Two routes in the Mekong region with the highest traffic volumes can be identified: one from Nanning to Kyaukphyu Port via Kunming and the other from Nanning to Dawei Port in Myanmar via Hanoi, Vinh, Vientiane, and Bangkok. Both indicate considerable room for development in terms of access to China and Myanmar's rapidly growing economies, particularly Kyaukphyu and Dawei. Moreover, high traffic volumes can be observed from Kyaukphyu to Bangladesh<sup>6</sup>, from Nanning and Kunming to other Chinese cities, around Bangkok and Ho Chi Minh City.

The second largest group of routes includes the following: One from Kunming through Hanoi to Hai Phong Port; one from Kunming to Bangkok via the NSEC route via Laos; one from Magway to Nay Pyi Taw and through Hpa Yar Gyi to Dawei Port; one from Bangkok to southern Vietnam via the TSS Southern Coastal Corridor; and one is the Vietnamese section of TSS Eastern Corridor.

Transport volume is greater in the TSS Southern Coastal Corridor than that in the original SEC. This is because the latter has a higher demand for access to Sihanoukville Port, and the original SEC has a relatively low demand for international trade between Thailand and Phnom Penh. The Myanmar section of the original NSEC is less utilised in the model because it is slightly farther than the Laos section.

Focusing on ADB's original three economic corridors, the EWEC is fragmented, the NSEC is expected to have some transport volume, and the SEC has a relatively large

<sup>6</sup> In the simulation, we allow border trade at the Maungdaw–Teknaf border.

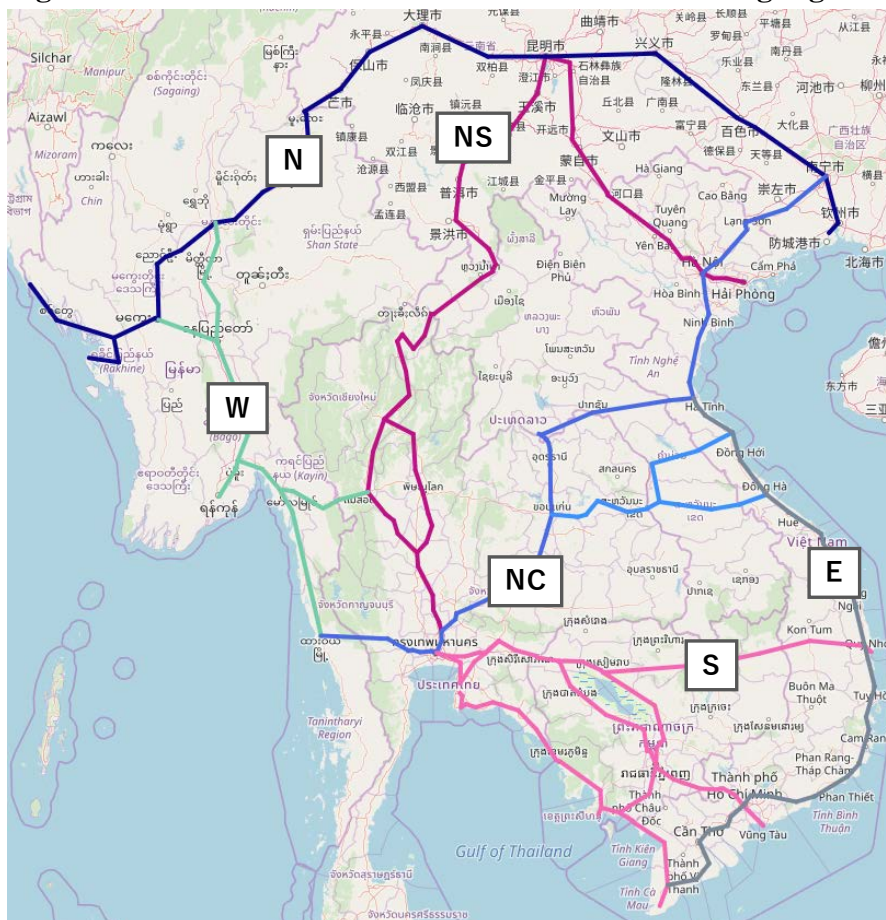
traffic. This is because, as has been criticised, the EWEC does not pass through the actual shipping route itself; however, some routes along the corridor are used as part of the transportation route between Bangkok and other cities.

This traffic volume differs from that in 2015 (Figure 2). Although the NSEC and national road No. 1 in Vietnam indicate a high traffic volume, the simulation proposed that the shortest route connecting Bangkok and Hanoi would be via the third Mekong Bridge and national road No. 8 in Laos. Economic growth in China and Myanmar and the development of new infrastructure such as the Vientian–Vinh Expressway will considerably change conditions in traffic flow.

### 3.4. Redefined economic corridors

Figure 11 presents the economic corridors identified from the simulation results. Precisely, the names and routes were chosen considering not only simulation results but also past ADB efforts, in addition to the possibility of discrepancies between simulation results and actual transportation patterns.

**Figure 11: Redefined economic corridors in the Mekong region through IDE-GSM**



Note: N: Northern  
W: Western



NS: North–South

NC: New Central

E: Eastern

S: Southern

Source: Authors. Background map is provided by OpenStreetMap under the Creative Commons Attribution-ShareAlike 2.0 license (CC BY-SA).

### **Northern Economic Corridor**

The most heavily travelled route from Nanning to Kyaukphyu Port through Kunming, Ruili–Muse, and Mandalay is designated as the Northern Economic Corridor because it roughly corresponds to the Northern Corridor in TSS. This includes the access route between Nanning and Fangchenggang Port. However, the TSS Northern Corridor extends from Mandalay to Tamu, whereas the redefined Northern Economic Corridor extends to the Kyaukphyu Port. This corridor should also include the route from Ann in Myanmar to Maungdaw near the border to Bangladesh.

### **New Central Economic Corridor**

An international corridor with a large traffic volume from Nanning to the Dawei Port in Myanmar via Hanoi, Vinh, Vientiane, and Bangkok has never been defined. It may be referred to as the New Central Economic Corridor because of a different route from the TSS North Eastern Corridor, a large traffic volume, and the inclusion of part of the TSS Central Corridor (Nakhon Ratchasima–Vientiane–Paksan). It includes two branch lines: one from Khon Kaen to Dong Ha and the other from Savannakhet to Vung Anh via Takhek.

### **North–South Economic Corridor**

In the second group of high-volume routes, a set of subcorridors from Kunming to Hai Phong Port and from Kunming to Bangkok via the NSEC is designated as the NSEC because they roughly correspond to the original NSEC. In Thailand, the simulation result indicates that the route through Pisanulok is selected; however, in reality, National Route 1 through Tak is also often utilised. Thus, both routes are designated as economic corridors. Within the NSEC, the section through Myanmar is not adopted owing to its small transportation volume.

### **Western Economic Corridor**

The route from Magway to the Dawei Port through Nay Pyi Taw and Hpa Yar Gyi is named as the Western Economic Corridor because it is close to the TSS Western Corridor. The economic corridor should include the section from Thaton to Tak. This economic

corridor will have branches from Mandalay to Nay Pyi Taw and from Hpa Yar Gyi to Yangon Port. Considering the approach of creating a corridor to a large city or a gateway port, the section from Magway to Kyaukphyu Port, defined as a part of the Northern Economic Corridor, may also be defined as the Western Economic Corridor. The route from Tak to Bangkok may be defined, which will be shared with the NSEC.

### **Southern Economic Corridor**

The route from Bangkok to southern Vietnam through the Southern Coastal Corridor will be part of the current SEC. The Cambodia section is also included in the SEC because the Poipet–Phnom Penh–Vung Tau route is important and the route from Siem Reap to Qui Nhon is also utilised in the simulation. The corridor may have Bangkok–Dawei section as ADB’s SEC. Unlike ADB’s current SEC, the corridor does not employ north–south routes from Savannakhet to Phnom Penh.

### **Eastern Economic Corridor**

The route from Vinh to Ca Mau in Vietnam has a large transport volume, and it should be named as the Eastern Economic Corridor according to TSS. This corridor could include the route from Vinh to Hanoi (or to Nanning).

This redefined economic corridor addresses many issues considered in defining ADB’s current three economic corridors. The lack of economic corridors in Laos and Myanmar; the lack of economic corridors in Yangon, Naypyidaw, and Vientiane; the lack of connection of Yangon Port in the economic corridors; and the lack of economic corridors covering major trade routes between PRC and Myanmar, Myanmar, and Thailand have been addressed. However, Route 13(N) from China to Vientiane was not included because it was not regarded as a main trade route in the simulation.

The redefined economic corridors do not include some of ADB’s economic corridors or routes by other initiatives. Representative cases are the EWEC middle section, Mandalay–Tamu section, and Myanmar section of the NSEC. These are not adopted as per the definition of this paper, i.e., from an economic perspective. Two possibilities exist in these routes: one is that those routes are designated as economic corridors because of political reasons and not economic ones. In this case, the designation of specific sections as economic corridors must be encouraged for local development and investment; however, it may be inappropriate in view of objective of economic corridors. If infrastructure investment specifications are set for the economic corridors, reconsidering whether infrastructure investment is worth is necessary. Another possibility is that although a potential demand exists for transportation, it has not been fully utilised due to the obstacles of the system and the hard infrastructure. Moreover, the transport volume has been reduced by simulation. In this case, promoting the development of hard infrastructure and implementing the necessary industrial packages along the road is



essential. Further studies are required to determine which of these cases is more likely.

## Conclusion

This paper uses IDE-GSM simulations to redefine an economic corridor in the Mekong region. As China's economic development progresses, the Northern Economic Corridor and its extension to Kyaukphyu Port are crucial. The New Central Economic Corridor, which runs to Dawei and Nanning via Bangkok, Vientiane, and Vinh, can be the main trunk road that represents the Mekong region. The NSEC is closer to ADB's original definition. The SEC is closer to ADB's current definition.

A new central economic corridor is a novel proposal of this paper. As stated by Isono and Kumagai (2013), the Dawei Port development is expected to considerably economically impact the Mekong region. The Vientiane–Vinh Expressway needs to be provided with high standards and capacity due to high transport demand. In addition, measures are needed to minimise the time and procedures at the border between Laos and Vietnam.

The redefined economic corridors did not adopt the EWEC. This is consistent with the findings of Banomyong and Sopadang (2009). From an economic perspective, the EWEC should be defined as a branch of the corridor that connects Bangkok and other areas.

Finally, recommendations for application to other regions are discussed. First, economic corridors must be easy to remember and understand to clarify priorities and promote stakeholder engagement. In this regard, the inclusion of almost all major highways such as ADB's current NSEC should be avoided. Second, economic corridors are not actually defined solely from an economic perspective. This paper is an experimental study, and we cannot argue that the EWEC should be discarded based on the conclusions of this paper. Nevertheless, a serious problem exists in defining economic corridors that do not have an economic perspective. This is because even if infrastructure projects along the corridor are promoted, they may not be utilised much. Clarifying the projects to be implemented and the economic activities to be expected to revitalise specific regions is necessary. IDE-GSM is an effective tool for discussing economic corridors from an economic perspective.

Finally, the definition of economic corridors must be consistent with the development plans and future economic projections. The fact that defining economic corridors accelerates infrastructure investment seems to contradict the fact that economic corridors cannot be properly defined without foreseeing infrastructure investment<sup>7</sup>.

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<sup>7</sup> However, actually there is an interdependence between economic corridors and infrastructure investment plans. Economic corridors should be designed with future infrastructure projects in mind, but the designation of economic corridors leads to the introduction of more infrastructure projects and prioritises infrastructure investment in some cases.

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## Appendix 1: Transport Costs in IDE-GSM<sup>8</sup>

Our transport cost comprises physical transport costs, time costs, tariff rates, and non-tariff barriers (NTBs). Physical transport costs are a function of the distance travelled; travel speed per hour; physical travel cost per kilometre; and holding cost for domestic/international trans-shipment 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 trans-shipment 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’<sup>9</sup> for 2008 and 2009, which includes manufacturers in Indonesia, the Philippines, Thailand, and Vietnam. Based on these parameters, we calculated 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 obtained the sum of physical transport and time costs for each pairing of two regions by industry (Cormen *et al.*, 2001).

We assumed that firms choose a transportation mode from among the following: 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  $\varepsilon_M$  denotes unobservable mode characteristics,  $Abroad_{ji}$  takes unity if regions  $i$  and  $j$  belong to different countries and zero otherwise;  $d_{ji}$  denotes the geographical distance between regions  $i$  and  $j$ .  $u_s$  denotes the industry dummy. When  $\varepsilon_M$  is independent and follows the identical type I extreme value distribution across modes, the probability that the firm chooses mode  $M$  is given by the following:

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

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

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<sup>8</sup> It is a modified version of the model of Kumagai and Isono (2011).

<sup>9</sup> This survey was conducted by the Economic Research Institute for ASEAN and East Asia.

The geographical distance affects firms' modal choices through a per-unit physical charge for shipments as well as shipping time costs due to the nature of the demand for shipments. Transportation time considerably influences the price of products that decay rapidly over time; for example, time-sensitive products include perishable goods (fresh vegetables), new information goods (newspapers), and specialised intermediate inputs (parts for Just-In-Time production). Lengthy shipping time may lead to a complete loss of commercial opportunity for products and their components, more likely to be significant for goods with a rapid product lifecycle and high demand volatility. Given the value of timeliness in selling a product, time costs are small for timely shipments (short transport time). In other words, time costs will be the highest for shipping by sea and the lowest for shipping by air. Furthermore, the physical transport costs will be highest for air and the lowest for the sea. Truck transport will have a medium level of costs compared with air and sea transport. Consequently, 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. First, 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. Second, the level of port infrastructure obviously differs among countries. This yields different impacts of the aforementioned two types of transport costs among shipping countries. We introduced country dummy variables ( $v_k$ ) to control such differences among countries in which reporting firms are located. Finally, qualitative differences between intra- and international transactions are controlled by introducing a binary variable (*Abroad*), taking unity if transactions are international 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 1). The four countries covered in the survey were Indonesia, the Philippines, Thailand, and Vietnam. The sample population was restricted to selected manufacturing hubs in each country (JABODETABEK area, i.e., Jakarta, Bogor, Depok, Tangerang, and Bekasi for Indonesia; CALABARZON area, i.e., Cavite, Laguna, Batangas, Rizal, and Quezon for the Philippines; Greater Bangkok area for Thailand; and Hanoi area and Ho Chi Minh City for Vietnam). 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 was restricted to one accessible by land transportation.

**Table 1: Combination of Trading Partners in the Dataset**

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

Source: The Establishment Survey on Innovation and Production Network.

Let us take a brief look at a firm's choice of transportation mode. Table 1 reports the combination of trading partners in our dataset. First, as mentioned above, firms in the Philippines and Indonesia are restricted to the ones with intra-national transactions, although most firms in the other countries in our dataset are also engaged in intra-national transactions. Second, a relatively large number of Vietnamese firms trade with China. Third, Table 2 presents the transportation mode by the location of firms, indicating that most of our sample firms chose truck. Intuitively, this may be consistent with the first fact that most firms trade domestically.

**Table 2: The Chosen Transportation Mode by Location of Firms**

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

Source: The Establishment Survey on Innovation and Production Network.

Table 3 presents the MNL result. First, in trading with partners abroad, firms likely choose air or sea transport. Second, the coefficients for distance are estimated to be significantly positive, indicating that the larger the distance between the trading partners, the more likely the firms choose air or sea transport. Specifically, this result implies that the two types of transport costs per distance are lower for air and sea transport than those for the truck. Third, the intercept term of distance in machinery industries has a significantly positive coefficient for air transport. This result may indicate a large amount of time costs in the machinery industry.

**Table 3: Result of Multinomial Logit Analysis**

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

Note:\*\*\*, \*\*, and \* indicate 1%, 5%, and 10% significance, respectively.

Source: Authors' calculation.

Finally, we conducted some simulations to get a more intuitive picture of the transportation modal choice. Specifically, employing our estimators, we calculated the distance between trading partners in which the two transportation modes become indifferent in terms of their probability. For instance, 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 a truck. In the calculation, we set Abroad to the value of 1, i.e., international transactions. Table 4 reports the results. In Bangkok, for example, firms in the machinery industry choose air or sea transport if their trading partners are located more than 400 km away. Firms in the food industry basically only use the truck.

**Table 4: Probability Equivalent Distance with Truck (Kilometre): Domestic and International Transportation from Bangkok**

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

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

We estimated some parameters necessary for calculating transport costs. Specifically, we estimated transportation speed and holding time. Our strategy for estimating those was straightforward and simple. We regressed 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  $\rho_1^M$  represent mode  $M$ 's holding time in domestic transportation and its additional time in international transportation, respectively. The inverse of  $\rho_2^M$  indicates the average transportation speed in mode  $M$ . We used 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 ordinary least square (OLS) regression results are reported in Table 5. Although some of the holding time coefficients, i.e.,  $\rho_0^M$  and  $\rho_1^M$ , are estimated as being insignificant, their magnitude is reasonable enough. As for the distance coefficient, its magnitude in case of sea transport and truck is reasonable, but disappointing and too far from the intuitive speed for air transport, say, around 800 km/h. One possible reason is that 'time' in our dataset always includes land transportation time to the airport. This will cause the air transportation speed to be understated.

**Table 5: Results of the OLS Regression: Holding Time and Transportation Speed**

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

Notes: \*\*\*, \*\*, and \* indicate 1%, 5%, and 10% significance, respectively. The dependent variable is transportation time.

Source: Authors' calculation.

We specified a simple linear transport cost function comprising physical transport costs and time costs. We assumed the behaviour of the representative firm for each industry as follows:

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

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

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

where  $dist_{ij}$  denotes the travel distance between regions  $i$  and  $j$ ,  $speed_M$  denotes travel



speed per one hour by mode  $M$ ,  $cdist_M$  denotes the physical travel cost per one kilometer by mode  $M$ , and  $ctime_s$  denotes 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 trans-shipment at ports or airports. Similarly,  $ttrans_M^{Intl}$  and  $ctrans_M^{Intl}$  denote the holding time and cost, respectively, for international trans-shipment at borders, ports, or airports.

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

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

**Table 6: 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 5
$ttrans_M^{Dom}$	0	11.671	9.01	hours	Table 5
$ttrans_M^{Intl}$	13.224	14.972	12.813	hours	Table 5 & Map
$ctrans_M^{Dom}$	0	190	690	US\$	Map
$ctrans_M^{Intl}$	500	N.A.	N.A.	US\$	Map

Notes: Costs are for a 20-foot container. The parameter  $ctrans_M^{Dom}$  is assumed to be half of the sum of border costs and trans-shipment costs in international transport from Bangkok to Hanoi. The parameter  $sttrans_M^{Dom}$  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 4, the transport cost  $C^{s,Air}$  should equal  $C^{s,Truck}$  in machineries and  $C^{s,Sea}$  should equal  $C^{s,Truck}$  in the other industries. Using this equality, we calculated  $ctime_s$  for each industry as in Table 7. The functions meet the above conditions.

**Table 7: Time Costs per One Hour by Industry Perceived by Firms ( $ctime_s$ ): US\$/hour**

	Food	Textile	Machineries	Automobile	Others
$ctime_s$	15.7	17.2	1803.3	16.9	16.5

Source: Authors' calculation.

Third, by substituting these parameters again, including  $ctime_s$  and  $ctrans_{Truck}^{Intl}$  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  $ctrans_M^{Intl}$ . Using the probability equivalent (international) distances in Table 4 again, we can calculate  $ctrans_{Air}^{Intl}$  and  $ctrans_{Sea}^{Intl}$  for each industry. Finally,  $ctrans_{Sea}^{Intl}$  is uniquely set as the average among the other industries. These parameter values are reported in Table 8. The functions obtained also satisfy the above conditions.

**Table 8: Costs for Trans-shipment 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 speed of railway are estimated by the same dataset and the same estimating equation. Due to the minimal usage of railways in international transactions in the dataset, we adopted the same value for the time and cost of international transactions as in trucks from Table 9. Finally, we set the cost per km as half the value of road transport<sup>10</sup>.

**Table 9: 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.

<sup>10</sup> The ASEAN Logistics Network Map 2008 offers an example where the cost per km 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. Railway has much larger economies of scale than trucks in terms of shipping volume, so some industries such as coal haulage incur much lower cost per ton kilometer. Therefore, we need to deduct this from the value in the ASEAN Logistics Network Map 2008.

The sum of TNTBs by countries is estimated by employing the ‘log odds ratio approach’, initiated by Head and Mayer (2000). Namely, we estimated 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 estimated for the ratio of ‘consumption of products from country  $j$  in country  $i$  ( $X_{ij}$ )’ to ‘consumption of products from country  $i$  in country  $i$  ( $X_{ii}$ )’. For brevity, we omitted an industry subscript. Specifically, such a ratio is given by the following.

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

$n$ ,  $a$ ,  $t$ ,  $\sigma$ , 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 assumed the following. First, the mass of varieties was assumed to be related to the size of the gross domestic product (GDP). Second, we assumed 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 were assumed to be expressed as the following.

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

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

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

$\pi$  and  $Area$  are circular constant and surface area, respectively.  $Cost$  denotes the sum of physical transport costs and time costs, of which computation is explained before. Finally, 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.

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

$u_i$  denotes fixed effects for country  $i$ . From a theoretical perspective, it denotes the log value of the product between *Border* and  $(1-\sigma)$ . Therefore, we computed 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 estimated the model by pooling the data for five sectors and controlling for sector fixed effects.

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

The estimation results by the OLS method are reported in Table 10. Almost all variables have significant coefficients with expected signs. 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. To obtain those in the other countries, we assumed that those in each country are highly correlated with her GDP per capita and regressed (log of) GDP per capita in addition to industry dummy variables on the estimates of these fixed effects. The estimation results are as follows.

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

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

**Table 10: OLS Results**

	Agriculture	Manufacturing	Services
GDP ratio	0.968*** (0.020)	1.346*** (0.011)	0.677*** (0.008)
Language	1.115*** (0.126)	0.684*** (0.070)	0.146*** (0.048)
Colony	0.508** (0.204)	0.173 (0.114)	0.268*** (0.078)
Contiguity	1.821*** (0.186)	1.090*** (0.103)	0.464*** (0.071)
Distance ratio	-0.555*** (0.086)	-1.000*** (0.036)	-0.016 (0.038)
Cost	-0.743*** (0.194)	-0.576*** (0.206)	-0.459*** (0.068)
GDP per capita ratio	-0.593*** (0.024)	0.134*** (0.013)	0.301*** (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. In the parenthesis is the robust standard error. All specifications include import country dummy variables.

Source: Authors' calculation.

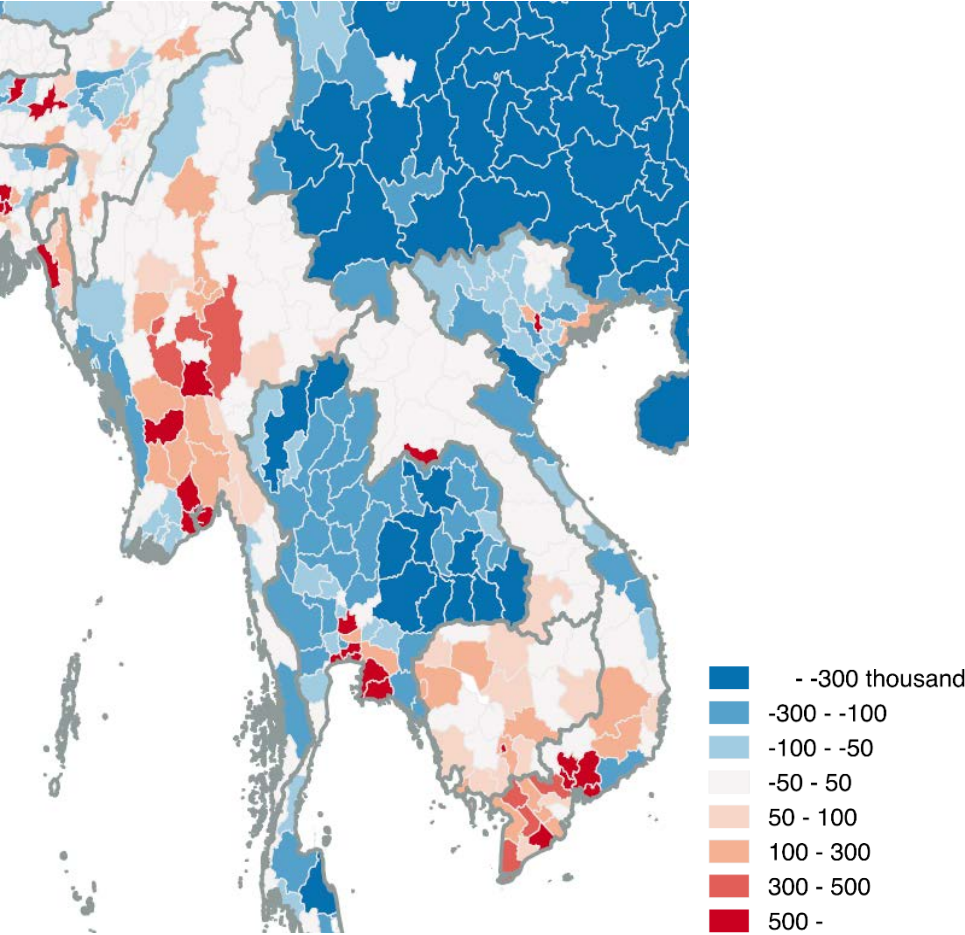
Next, we obtained NTBs by subtracting tariff rates from TNTB. Our data source for tariff rates is the World Integrated Trade Solution, particularly Trade Analysis and Information System raw data. For each trading pair, we aggregated the lowest tariff rates among all available tariff schemes at the tariff-line level into single tariff rates for each industry by taking a simple average. Available tariff schemes include multilateral free trade agreements (FTAs) (e.g., ASEAN+1 FTAs) and bilateral FTAs (e.g., China–Singapore FTA) alongside other schemes such as the Generalised System of Preferences. Moreover, we considered the gradual tariff elimination schedule in six ASEAN + 1 FTAs in addition to 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. Tariff rates in Japan and ASEAN forerunners against members are for simplicity assumed to linearly decrease to become final rates in 2018, and those for ASEAN latecomers decrease linearly to final rates in 2026. ‘Final rates’ considers the final rates set in each agreement. Namely, even if tariff rates for a product were not zero in 2009, they are set to zero in 2026 if they involve preferential products. We obtained information about whether each product finally attains zero rates in ASEAN + 1 FTAs from the FTA database developed by ERIA. We set final rates for all products in the case of AFTA at zero due to the lack of such information. As a result, we separately obtained bilateral tariff rates and importer-specific NTBs by industry on a tariff-equivalent basis. Finally, our total transport costs are the product of the sum of physical transport and time costs and the sum of tariff rates and NTBs.

Another important setting on transport cost is the ‘cumulation rule’ in multilateral FTAs, particularly ASEAN+1 FTAs and AFTA. There are several types of cumulation rules: bilateral, diagonal, and full. Some scholarly studies have quantified the trade creation effect of diagonal cumulation. Hayakawa (2014) examined Thai exports to Japan, and the tariff equivalent of the diagonal cumulation rule in AJCEP is estimated at around 3%. Based on this estimate, we formalised 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.

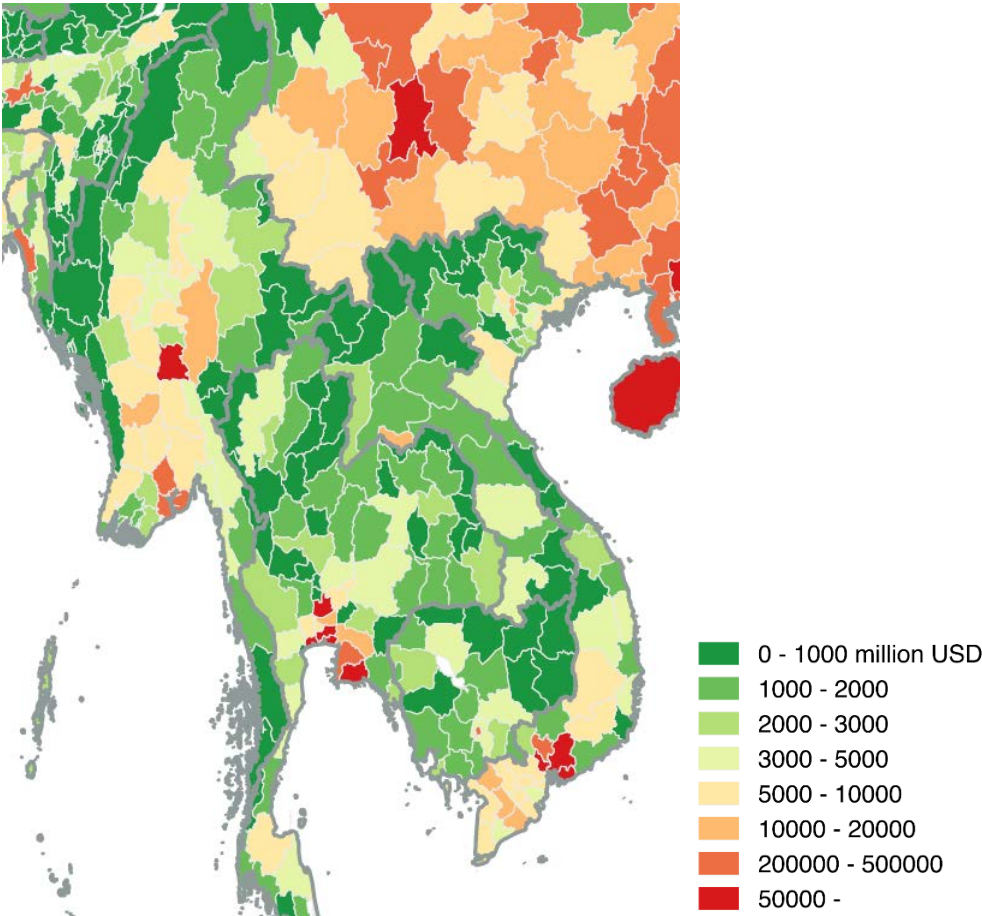
Appendix 2: Supplementary figures

Figure 12: Population changes (2015–2030)



Source: IDE-GSM simulation result.

Figure 13: GRDP (2035)



Source: IDE-GSM simulation result.