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GEOGRAPHICAL SIMULATION ANALYSIS FOR LOGISTIC ENHANCEMENT IN EAST ASIA

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EXECUTIVE SUMMARY

The IDE Geographical Simulation Model (GSM) was developed as an economic geography model for the purpose of predicting the effects of infrastructure development projects on the economy at the subnational level. The third-generation IDE-GSM differs from the second-generation version in the following points: (1) geographic coverage has been expanded to cover ASEAN 10+Bangladesh as well as parts of China and India, and (2) it incorporates realistic modal choice between land, sea, and air transport. These improvements enable better analysis of a wider variety of scenarios and provide more reliable results.

The third-generation IDE-GSM is a cutting-edge economic model that incorporates realistic geography and modal choice. Various analyses show that the economic impacts of logistic infrastructure developments are quite complicated and differ significantly by industry. Development should thus be carefully planned and, to that end, an analytical model like IDE-GSM has much to contribute.

The third-generation IDE-GSM confirms that regional infrastructure development projects would benefit most regions along corridors and near ports and airports. However, large-scale infrastructure development may widen existing income gaps, i.e., rich regions may become richer and poor regions may become poorer. In particular, intranational economic gaps may widen during the phase of economic development, given the restrictions on the international mobility of the labor force.

We should be very cautious when considering regional infrastructure development because the economic improvement of all involved regions is not assured. Infrastructure development might create winning industries and losing industries within a region. The economic effects of infrastructure development need to be carefully analyzed using proper analytical tools. IDE-GSM is such a tool and contributes to sound evaluation and prioritization of certain types of planned infrastructure development projects.

The test simulations presented in this paper revealed that an infrastructure development

project might lead to quite drastic modal shifts for certain origin-destination combinations. As a result, there is a possibility of under- or overunitization of specific loads/ports/airports.

Thus, we need to plan infrastructure development projects with consideration of all modes of transport. In addition, the regions affected by an infrastructure development project are often wider than one can imagine. It is thus a sensible policy option to establish an international body to coordinate regional transport infrastructure development projects. Again, an economic model with a realistic geography and modal choice like IDE-GSM has a role to play in predicting the possible modal shifts triggered by transport infrastructure development projects.

IDE-GSM is a complex system, and it is hard to predict without accurate data and a solid simulation model. We need to develop IDE-GSM further as well as facilitate the coordination of a geographical statistical system among member countries of the Economic Research Institute for ASEAN and East Asia (ERIA).

To conduct more accurate simulations with richer implications, more precise regional economic and demographic data are required at the subnational level in each country and at the subprovincial level in China and India. The establishment of uniform territorial units for geographical statistics like the Nomenclature of Territorial Units for Statistics (NUTS) in the European Union (EU) is needed. We need harmonized data as well as harmonized data collection methods in East Asia. ERIA is a suitable body to conduct capacity building for officials in national corridors connecting regions.

We also need more precise data on routes and corridors connecting regions. Information on the main routes between cities, times, and modes of transport (road, railway, sea, and air) are indispensable. Data on border costs such as tariffs and nontariff barriers due to inefficient customs clearance are also crucial for the better analyses.

Geographical Simulation Analysis for Logistic Enhancement in East Asia

S. KUMAGAI, T. GOKAN, I. ISONO, K. HAYAKAWA, and S. KEOLA

Abstract

The IDE/ERIA Geographical Simulation Model (GSM) has developed as an economic geography model that predicts the effects of infrastructure development projects on the economy at the subnational level. The third-generation IDE/ERIA-GSM differs from the second-generation one in the following points: (1) geographic coverage is expanded to the east coast of India, Indonesia, and the Philippines; and (2) it incorporates realistic modal choice between land, sea, and air transport. These improvements enable the analysis of a wider variety of scenarios with more reliable results.

Keywords: Economic Geography; Infrastructure Development; Modal Choice

JEL Classification F15; O53; R15; R40

1. Introduction

In 2006, the first-generation IDE/ERIA Geographical Simulation Model (IDE/ERIA-GSM) was developed as a simple application of Krugman's Core-Periphery Model (1991). Then it was expanded with two major objectives: (1) to determine the dynamics of locations of populations and industries in East Asia in the long term and (2) to analyze the impact of specific infrastructure projects on the regional economy at the subnational level.

The initial simulations using IDE/ERIA-GSM revealed that (1) border costs play a big role and (2) nominal wages matter more than expected. In the simulations, elimination of border costs seemed to be much more effective than the development of physical infrastructure alone. In East Asia, there is quite a large difference in nominal wages not only internationally but also intranationally. It is so large that small advantages in location cannot counter the centripetal force of some central regions that attract the inflow of population due to higher nominal wages.

To make it possible for IDE/ERIA-GSM to derive more concrete policy implications, the second-generation IDE/ERIA-GSM model was developed in 2008. Most notably, the industrial sectors in the model were expanded from three to seven. This enabled the prediction of the impact of infrastructure development for each industry more precisely and derived policy implications that are more industry specific.

Building on these efforts, the third-generation IDE/ERIA-GSM model was developed from 2009 to 2010. The main points of improvement are (1) the extension of the geographical coverage of the model from continental Southeast Asia (CSEA) to all ten members of the Association of Southeast East Asian Nations (ASEAN) plus some parts of China and India and (2) the inclusion of sea and air routes and modal choice between land, sea, and air traffic.

This paper is structured as follows: section 2 explains the background and objectives of the model; section 3 explains the features of the system; section 4 explains the model and parameters used in the simulations and the system of modal choice; section 5 depicts the current status of economic geography in the covered region; section 6 explains scenarios and results of the simulations; section 7 states the conclusions and the policy implications of this study.

2. Background and Objectives

2.1 Brief survey of literature

Since the beginning of the 1990s, spatial economics has been studied extensively as a cutting-edge field of economics. It explicitly incorporates "space," which had been not been handled well by mainstream economics, into its theory, and treats various geographic aspects of economic phenomena in the framework of general equilibrium. The dramatic increase in research on spatial economics in the last decade coincided with the globalization and regional integration of the world economy, as represented by the formation of the European Union (the EU) and the North American Free Trade Agreement (NAFTA).

In East Asia, the evolution of *de facto* regional integration makes it apparent that traditional theories of international trade are not adequate to explain the actual trade and investment flows in this region. Spatial economics is indispensable for analyzing regional integration in East Asia because the existence of China and India, both of which have abundant, low-cost labor and a huge domestic market, requires a theory that incorporates the notion of increasing returns.

Although the theory of spatial economics made huge progress in the last decade, empirical application of the theory has not flourished so far. In international economics, the “home market effect,” one of the important concepts of spatial economics, has been a focal point of empirical research and a great deal of effort has been made to prove or disprove the existence (or nonexistence) of this effect (Davis and Weinstein 1999; Hanson and Xiang 2004). Unfortunately, most of the studies that have been done lack actual “geographic factors” because they set “nation” as a unit of analysis.

Some realistic simulation models appeared in the 2000s, although these numerical simulations are rather minor (Fujita and Mori 2005, 396-397). In case of the EU, there are several works to simulate the effects of the infrastructure development. Teixeira (2006) applied a NEG-based simulation model to evaluate the transport policy in Portugal and concluded that the development of transport networks so far has not contributed to the spatial equity in the region. Bosker et al. (2007) divided the EU into 194 Nomenclature of Territorial Units for Statistics (NUTS) II-level regions to see the effect of further integration of the EU based on Puga’s (1999) model. The authors found that further integration leads to higher levels of agglomeration.

2.2 Objectives of IDE/ERIA-GSM

Analysis using IDE/ERIA-GSM has two major objectives. The first objective is to know the dynamics of the location of population and industries in East Asia for the long term. Although there are many analyses to forecast the macroeconomic indices in East Asia at the national level, there has been no analysis using the models to forecast economic development in East Asia at the subnational level except for a scant amount of literature. In an era of regional economic integration, economic analysis at the national level is not enough to provide useful information for regional economic cooperation.

The second objective is to analyze the impacts of specific infrastructure projects on the regional economy at the subnational level. It is difficult to prioritize various infrastructure development projects without the proper, objective evaluation tools. IDE/ERIA-GSM was developed to provide an objective evaluation tool for policy recommendation in infrastructure development.

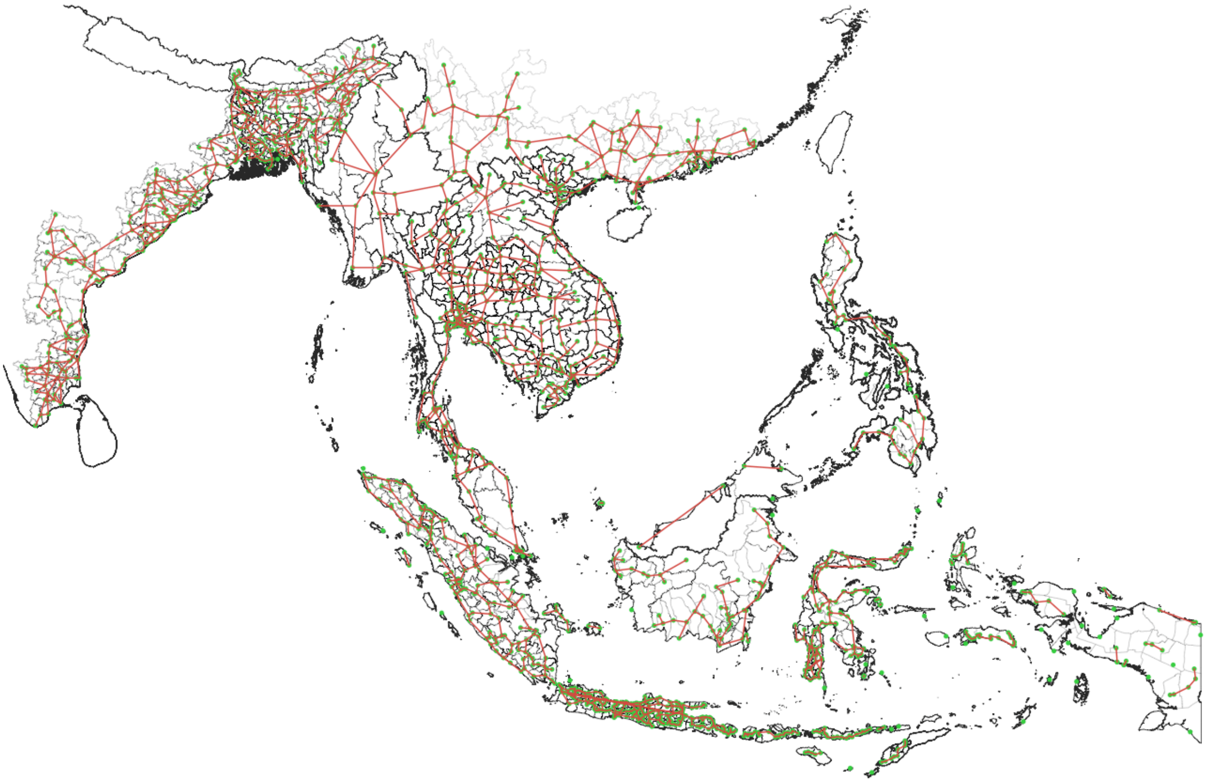
3. Features of the System

3.1. Basic feature of the system

IDE/ERIA-GSM covers the following 12 countries and regions in the analyses (Figure 1).

- Singapore
- Malaysia
- Thailand
- Myanmar
- Cambodia
- Lao PDR
- Indonesia
- Philippines
- Vietnam
- China (Yunnan, Guangxi, and Guangdong provinces)
- Bangladesh
- Western India

Figure 1: Regions and Routes (land only) included in IDE/ERIA-GSM



Each country/region is subdivided into states/provinces/divisions. Each state/province/division is represented by its capital city, and there are a total of 956 subnational regions. The following data are used in each subnational region:

- GDP by sector (primary, secondary[1], and tertiary industries)
- Employee[2] by sector (primary, secondary, and tertiary industries)
- Longitude and latitude
- Area of arable land[3]

In addition to these cities that have population and economic activities, 693 cities, ports, and airports, which are topologically important, are included in the model.

The number of route data amounts 2,694. Among them, 1,890 land routes between cities are included, based mainly on the "Asian Highway" database of the United Nations Economic and Social Commission for Asia and the Pacific (UNESCAP). The actual road distance between cities is used; if road distance is not available, slant distance is employed. Air and sea routes are compiled from the data set assembled by the team of the Logistics Institute - Asia Pacific (TLIAP), and 488 sea routes and 270 air routes are selectively included in the model at this moment.

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[1] The secondary sector is divided into five industries, namely, automotive, electrical and electronic (E&E) products, textile and garments, food processing, and other manufactured goods.
[2] GMS treats population and employee as the same thing in this version.
[3] If subnational data of arable rand is not available, national-level data is used. National area of arable land is distributed to each subnational geographical unit proportional to its land area.

3.2. Advantages of the system

IDE/ERIA-GSM has the following three advantages.

Realistic enough to model the real world

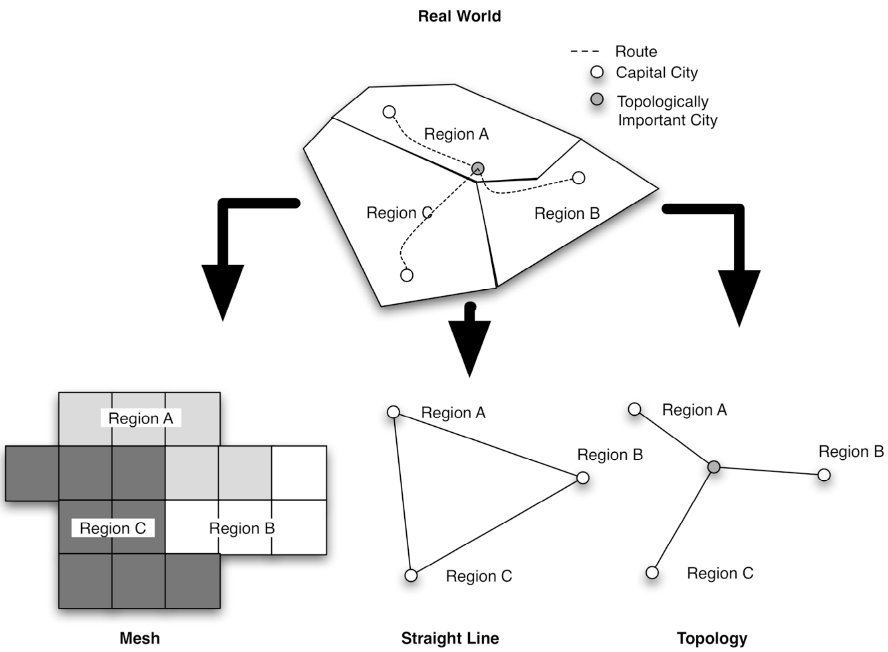
The first advantage of IDE/ERIA-GSM is that it incorporates a realistic topology of cities[4] and routes between them. In case of theoretical studies in spatial economics, "geography" is incorporated in the model as cities on the line or cities on the circle (the so-called "race-track economy" in Fujita, Krugman, and Venables, hereafter to be referred to as FKV 1999). On the other hand, the precedent empirical models used to incorporate geography as "mesh" or "grid" representation or a "straight line" representation, which simply connects cities as places of production and consumption to one another by straight lines. There is no topology, or geography in these models refers to the distances between cities.

IDE/ERIA-GSM differs from these models in that it incorporates geography as a "topology" of cities and routes. The topology representation of geography has three major advantages over the mesh representation. First, it makes it possible to incorporate the realistic choice of routes in logistics whereas the mesh representation does not necessarily incorporate routes explicitly. A problem of topology representation is in calculating the minimal distance between any two cities in consideration of every

[4] The word "city" is used in GSM in the administrative sense. However, GSM does not exclude the possibility of defining "city" in terms of a more realistic area according to actual economic activities.

possible route between them. Fortunately, Warshall-Floyd method provided the solution for the problem, which we used.

Figure 2: Three Representations of Geography



Source: Kumagai (2010)

The second advantage of topology representation is that it requires fewer data on cities or points compared with the mesh representation, which requires various data for a vast amount of meshes. IDE/ERIA-GSM uses 956 capital cities to represent the whole region. If the mesh representation (say, 10km x 10km) is used, we need the data for more than 65,000 meshes for the same region. Although we can reduce the number of meshes by using a larger mesh, "100km x 100km x 665 meshes," for instance, is too rough to capture the geographical feature of the region.

There are a few more minor advantages of the topology representation of geography. It is possible to add "interchange city," without taking into consideration population or industry just to capture the realistic topology of cities and routes. The third-generation IDE/ERIA-GSM has 517 topologically important cities/ports/airports. It is also possible to put "border costs" explicitly at the routes' border crossing, enabling IDE/ERIA-GSM to take into account the various costs at border controls. In addition to that, incorporating "routes" explicitly makes it possible to incorporate the difference in the quality of roads by setting different "average speed" running on it.

Flexible enough for future extension

IDE/ERIA-GSM is programmed in Java™, that is, it uses object-oriented programming (OOP) and is platform free. OOP enables IDE/ERIA-GSM to be extended and easily modified. It is able to run different economic models with minimal changes in the program. Actually, to divide manufacturing sector into five industries in the second-generation model and to incorporate modal choice in the third-generation model, the modifications made in the program were relatively small.

IDE/ERIA-GSM is programmed as three-layered hierarchy (world-country-city), and it is possible to control various parameters at any level of the hierarchy. For instance, it is possible to set different parameters for international, intranational, and interindustry migration within a city.

Well integrated with graphical output methods

For geographical simulations, it is quite important to check the data graphically. As the geographical database is complicated, these data should be checked graphically to see if each city is located in the correct place and if the routes between them are topologically correct. When the results of the simulation come out, it is also necessary to check them graphically in order to analyze the geographical tendency of the distribution of population and industries as well as the routes, mode, and volume of transportation.

IDE/ERIA-GSM is well integrated with graphical output methods. It is able to check the location of cities and the routes between them using an Ajax application based on Google™ Maps, and a more detailed graphical analysis is possible by using R (statistical language) and *maptools* package.

4. Explanation of the Model

4.1. Brief explanation of spatial economics

Before going into the detailed structure of IDE/ERIA-GSM, allow us to explain spatial economics, which is sometimes called the "new economic geography." This is the theory behind the model. Spatial economics explains the spread of economic activities within a general equilibrium framework. The main ingredients of the spatial economics are (1) increasing returns; (2) imperfect competition; (3) love for variety; and (4) endogenous agglomeration forces. With increasing returns in production activity, firms can enjoy externalities as explained by A. Marshall (1890, 1920). Imperfect competition avoids the backyard capitalism implied in the spatial impossibility theorem, that is, imperfect competition (monopolistic competition) guarantees the demand for goods even if transport costs are incurred. Love for variety implies that a large variety of consumer goods improves consumers' welfare as explained by Haig (1926), and a large variety of inputs improves firms' productivity. Love for variety spurs demand for goods produced in distant markets. With regard to endogenous agglomeration forces, economic activities agglomerate as a consequence of the exogenous uneven distribution of resources or as a consequence of the economic activities themselves. Call the former "first nature" and the latter "second nature." Spatial economics focuses mainly on the second nature, although the following simulation models adopt both the first and second natures.

The distribution of economic activities is decided by the balance of agglomeration forces against dispersion forces. There are many types of agglomeration and dispersion forces. Therefore, the observed spatial configurations of economic activities are also varied. With exogenous shocks, the spatial structure is organized by itself, and the core-periphery structure evolves through structural changes.

The endogenous agglomeration forces bring circular causality. Circular causality is formed by market-access effects and cost-of-living effects. In terms of market-access effects, concentration (or an increase in demand by immigrants) enlarges the market. Suppliers locating in a large market can sell more, since goods that are not transported between regions are cheaper. Obviously, this effect becomes weak when transport costs are low. More important, under the increasing-returns-to-scale production technology, the increase in the number of suppliers in a larger market is more than proportional to the expansion of the home market. As a result, goods in excess of local demand are exported.

The second force causing a concentration is cost-of-living effect. The price index of goods becomes lower in a region where many suppliers gather. As goods are produced locally, the prices of most of these goods do not include transport costs. This allows prices of goods to remain low, which then induces more demand in the region.

This effect works better when transport costs are high and the mill price is low. The market-access effects and cost-of-living effects reinforce each other. Because the former lures supply and the latter attracts demand, these two effects form a circular causality in which economic activities agglomerate in a region. That is, an increase in either upstream or downstream firms encourages further increase in the other type of firms in the region, as explained by Hirschman (1958). For this same reason, an increase in either consumer or producer provides the incentive for the other to agglomerate in the region.

On the other hand, Krugman (1991) uses market-crowding effects as the dispersion force. Because of the decrease in the general price index due to concentration, the price charged by a specific firm becomes relatively high, resulting in lower demand for the goods. This effect becomes weaker as transport costs decrease.

Summing up these three effects, Krugman (1991) shows that the symmetric structure is maintained when transport costs are high enough, whereas core-periphery structure emerges when transport costs are low enough. In the formalization, transport costs between regions are exogenous factors and express all distance resistance. Mobile workers choose among regions based on wage rates and prices. When transport costs are high enough, the dispersion force overcomes the agglomeration forces. Firms cannot afford to engage in a harsh price competition even in a slightly larger market because the profit from the distant market is small. Thus, economic activities disperse. On the other hand, as transport costs decrease enough, agglomeration forces surpass the dispersion force. Firms can enjoy the benefits of large markets and low procurement cost even with harsh price competition by locating in a large market. This is because the profits from distant markets are large. Therefore, economic activities agglomerate in a region.

By introducing another dispersion force (such as land use and agricultural goods) with positive transport costs, economic activities may disperse even if the transport costs are extremely low.

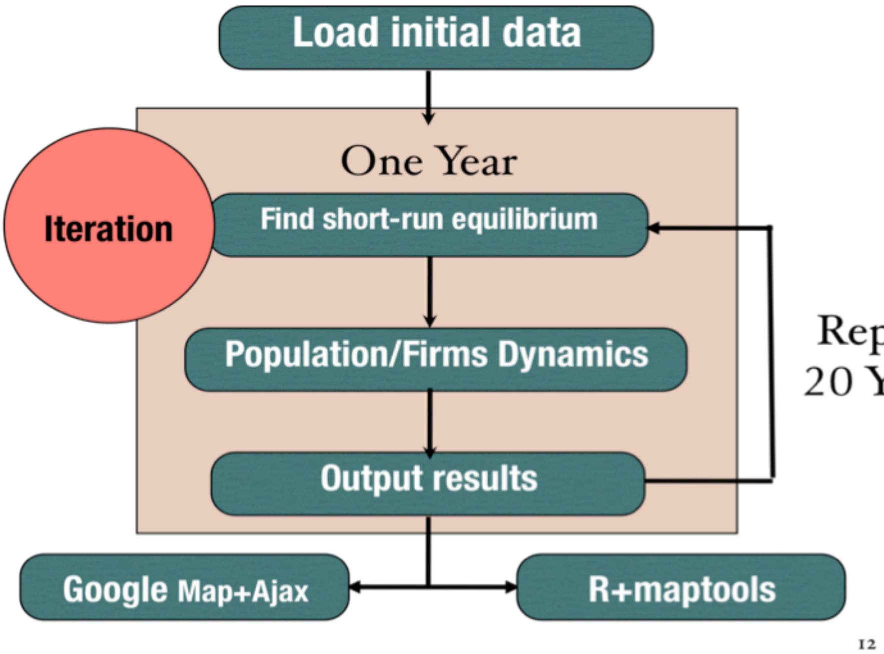
Consequently, to derive a policy implication for a circumstance, one may need to consider more realistic settings. Furthermore, the interaction described here is applicable in a situation where the economy consists of two or three regions in literature. For an economy with more regions, the use of a computer in the study becomes more crucial.

4.2. The structure of the model

IDE/ERIA-GSM was essentially based on Krugman (1991) and then extended to incorporate multiple industrial sectors and intermediate goods. So the structure of the current-generation IDE/ERIA-GSM is quite similar to the model in Chapter 14 of FKV. The detailed model structure is explained in Appendix A.

IDE/ERIA-GSM works as Figure 3.

Figure 3: The Computational Procedure of IDE/ERIA-GSM



1. Load initial data

The data on regions and routes are loaded from prepared CSV files. The regional data and the routes data should be compatible. For instance, all the names of cities on the routes data should appear in the regional data together with the other attributes of the city (region), especially the latitude and longitude.

2. Find short-run equilibrium

IDE/ERIA-GSM calculates the short-run equilibrium (equilibrium under a given distribution of population) values of such items as gross domestic product (GDP), employment, nominal wage, price index and so on, by sector based on the distribution of population. IDE/ERIA-GSM uses the iteration technique to solve the multiequation model. The detailed equations are proposed in Appendix A.

3. Population Dynamics

Once the short-run equilibrium values are found, IDE/ERIA-GSM calculates the dynamics of the population, or the movement of labor, based on the difference in real wages among countries/regions/industries. IDE/ERIA-GSM is able to set the speed of adjustment differently for intercountry/inter-region/interindustry labor movement.

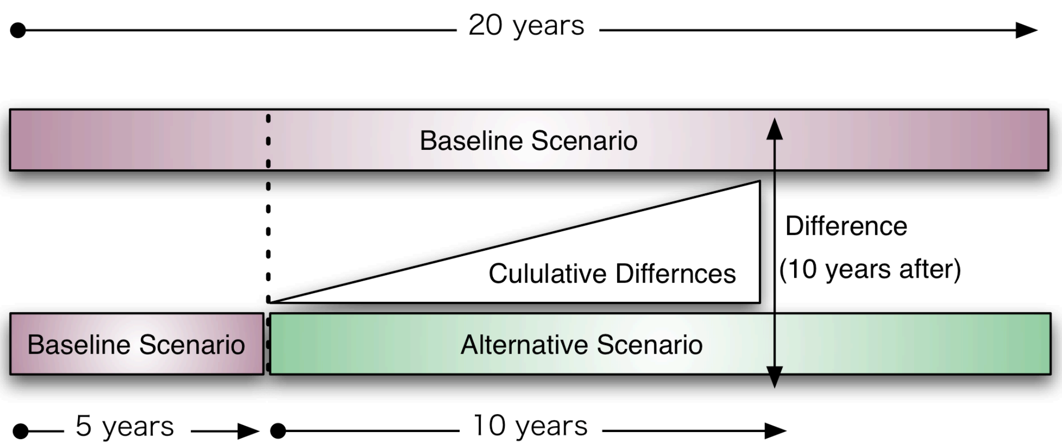
4. Output Results

To examine the related variables in time series, IDE/ERIA-GSM exports the equilibrium values of GDP by sector, employment by sector, nominal wage by sector, price index, and so on, for every single year in CSV and XML formats. These can be checked using Google™ Maps or a statistical language.

5. Back to #2.

Now back to the second step—find the new equilibrium under the new distribution of population. The return to the second step in the calculation process implies that time has advanced one year. In the analyses in this paper, the simulation is run for 20 years, and the cumulative difference during the 10 years after the scenario change and the difference at 10 years after are used to compare the two scenarios (Figure 4).

Figure 4: Comparing the Scenarios



4.3. Important parameters

Transport Costs

Transport costs are defined by industry. The first two generations of IDE/ERIA-GSM implemented the traditional “iceberg” transport costs. Thus, for instance, T=1.20 means that 1.00 out of 1.20 units of goods shipped from one part of CSEA arrived in another part of CSEA. It is understood that bringing goods from one part of CSEA to another requires a 20 percent overhead cost on the price of the goods.

In the third-generation IDE/ERIA-GSM model, transport costs are handled in a completely different way compared with the past two models. First, we calculated the money equivalent transport costs of transporting one 20-foot container by industry, mode, and distance. Then we calculated the percentage of these transport costs against the value of one 20-foot container filled with the following goods, namely, automotive products, electrical and electronic products (E&E), textile and garments, food, and other manufactured goods. This number is treated as T_{ijkm}, the transport costs between city *i* and *j* for goods *k* by mode *m.* The details are described in Appendix B.

Elasticity of Substitution

The elasticity of substitution between goods is also defined by industry and is represented by the symbol σ. The symbol σ in the manufacturing sector ranges from 5 to 10; in the service sector, σ equals 3. (See Appendix C for detailed explanation.) If σ=1.0, it means that two goods are perfectly differentiated and cannot substitute for each other. On the other hand, if σ is quite large, two goods are almost perfect substitutes for each other. So σ=3 means the goods are highly differentiated for the service sector.

Parameters on Labor Mobility

Parameters on labor mobility is set on three levels, namely, international labor mobility (γ_N), intranational (or intercity) labor mobility (γ_C), and interindustry labor mobility (γ_I) within a region. What does γ mean? If γ=0.1, it means that a country/region/industry with two times higher real wages than the average attracts 10 percent labor inflow a year.

Set γ_N=0. This means that the international migration of labor is prohibited. Although this looks like a rather extreme assumption, it is reasonable enough, taking into account the fact that most ASEAN countries strictly control incoming foreign labor.

Set γ_C=0.02. This means that a region with two times higher real wages than the national average induces 2 percent labor inflow a year.

Set γ_I=0.05, too. This means that an industrial sector with two times higher real wages than the average in the region induces 5 percent labor inflow from other industrial sectors a year.

Other parameters

Set consumption share of manufactured goods (μ) at 0.279 and the same share of services at 0.636. Thus, that of agricultural goods is at 0.088. The value of μ is based on the aggregate production share of each industry in the region. This must be calibrated and differentiated for each country. However, for simplicity's sake, identical utility function is currently used for consumers for all countries.

Set costs share of labor in the production of agricultural goods (β) at 0.633 and that of manufactured goods at around 0.2 to 0.3. Thus, the input share of intermediate goods in the production of manufactured goods is around 0.7 to 0.8. These parameters are set based on the Input-Output (I-O) table for Thailand in 2000. This should be calibrated for each industry more carefully in the future.

Parameters by industry

The first generation of IDE/ERIA-GSM had three sectors: (1) agriculture, (2) manufacturing, and (3) service. The service sector was incorporated as just a sector that incurs extremely high transport costs, other things being equal to the manufacturing sector. The second generation of IDE/ERIA-GSM had seven sectors, namely, (1) agriculture, (2a) automotive, (2b) electric and electronics, (2c) textile and garments, (2d) food processing, (2e) other manufactured goods, and (3) service. There are three possible sources of difference of industry in this model, as well as the configurations of transport costs and initial geographical distribution:

a) Elasticity of substitution (σ)

b) Share of labor input (β)

c) Share in consumption (μ)

From various sources, we specify the parameters for each sector temporarily as Table 1, and it is assumed to be common in all countries. For future expansion, we need to use different parameters for different countries. The values for σ are calibrated considering various factors and the previous studies like Hummels (1999), and β are calculated based on I-O table for Thailand in 2000 by IDE. The value of μ is based on the aggregate production share of each industry in the region.

Table 1: Parameters specifying each industry

Industry	σ	β	μ
Automotive	7	0.262	0.009
Electronics & Electric	7	0.228	0.044
Textile, Garments	9	0.329	0.043
Food Processing	9	0.303	0.035
Others	8	0.281	0.154

4.4. On the modal choice

The third generation IDE/ERIA-GSM model incorporates "modal choice." In the model, each firm decides the route and mode of transport considering both money and time costs. The details of the procedure to derive the transport costs are shown in Appendix B. IDE/ERIA-GSM adopts the modal mix that minimizes the total transport costs and calculates an iceberg-like transport parameter, dividing minimum transport costs by the standardized value of the goods by industry.

Figures 5-1 and 5-2 are examples of the modal choice between Jakarta, Indonesia and Kunming, China. Figure 5-1 shows the routes used by the textile and garments industry, which incur relatively small time costs. Figure 5-2 shows the routes adopted by the E&E industry, which incurs relatively large time costs. The former industry tends to use land/sea routes, while the latter industry tends to select air route.

Note that the current model of modal choice in IDE/ERIA-GSM has room for improvement. For instance, air/sea route data do not fully reflect current reality. So the modal choice in IDE/ERIA-GSM tends to choose routes that use the minimum distance to transport goods while neglecting the "hub-ness" of nearby ports/airports.

Figure 5-1: Modal Choice between Jakarta and Kunming (Textile & Garments Industry)

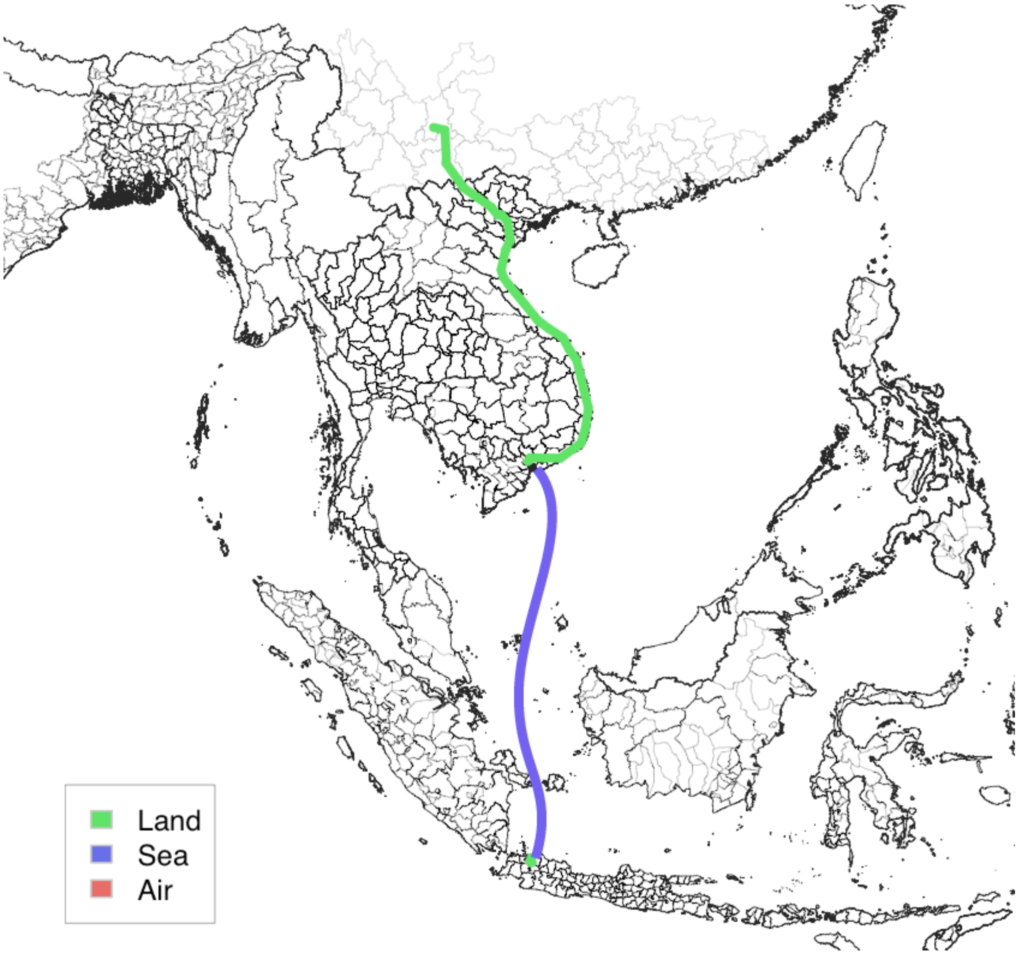
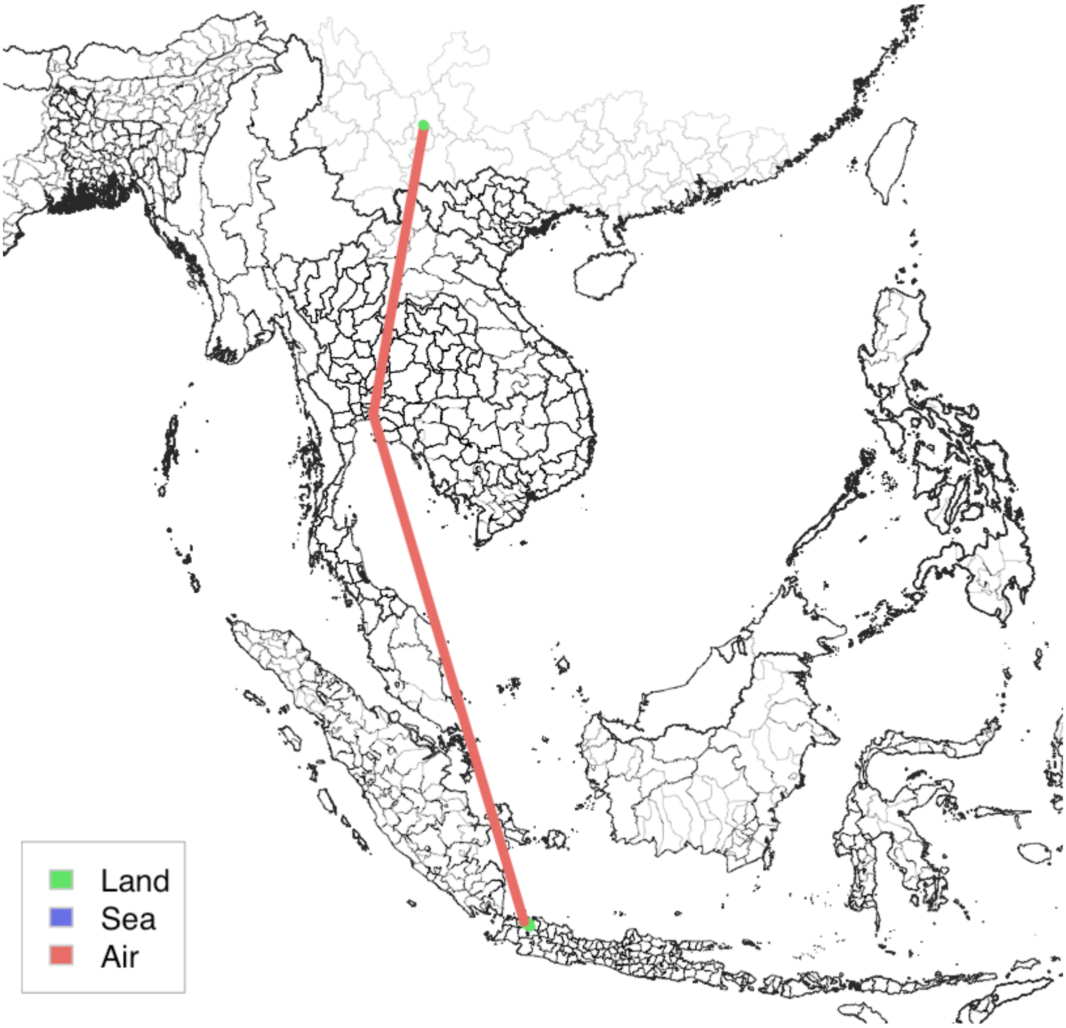


Figure 5-2: Modal Choice between Jakarta and Kunming (E&E Industry)



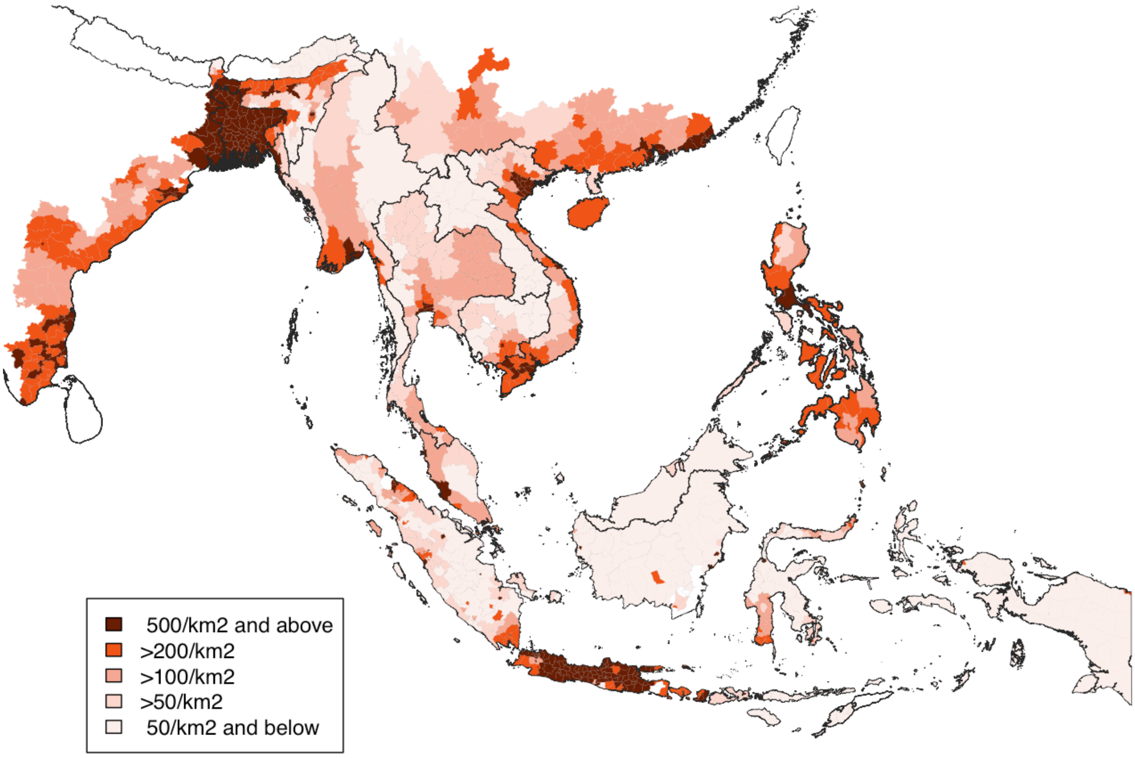
5. The Current State of Economic Geography in East Asia

5.1 Population

Figure 6 shows the population density of the region covered in the simulation. We will find some agglomeration of population in this region. For instance, the population of Indonesia agglomerates in Java Island. Bangladesh is uniformly highly populated.

China and India seem to have a few highly populated regions. For the other countries, the areas surrounding capital cities are highly populated, although Vietnam has two core cities—one in the north (Hanoi) and another in the south (Ho Chi Minh).

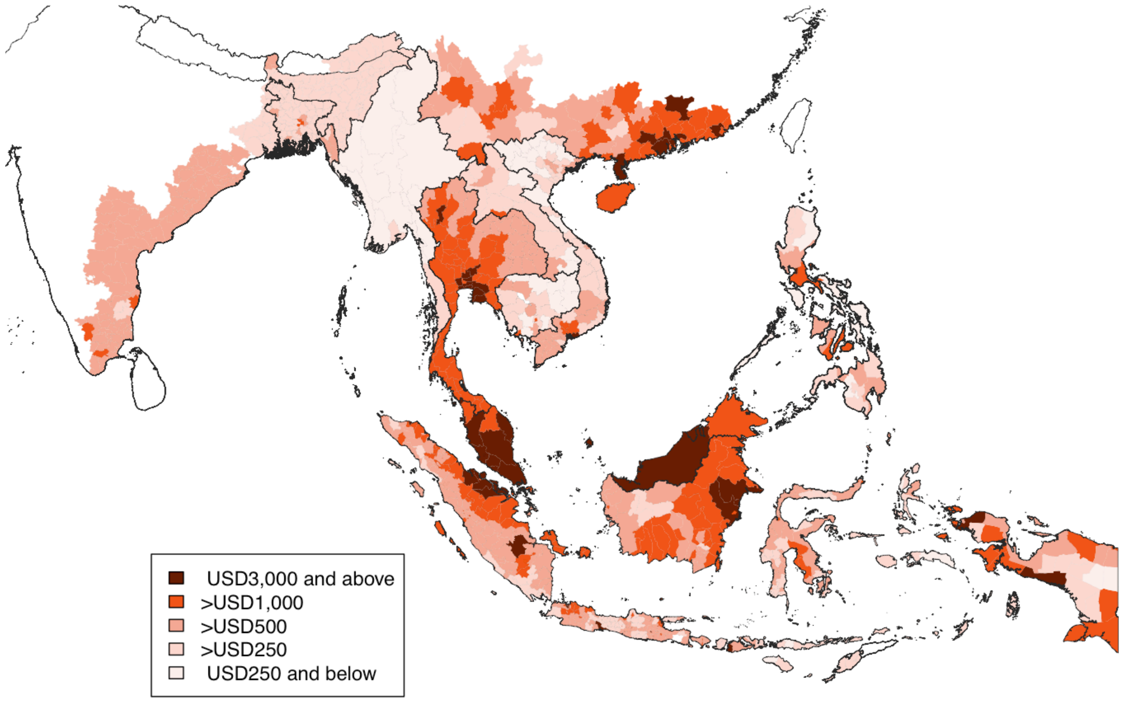
Figure 6: Population Density (2005)



5.2 GDP per capita

Figure 7 shows the GDP per capita of the region covered in the simulation. There is a large diversity in the income level. Singapore is an exceptionally rich region, and Malaysia and the other regions that contain the capital cities of each country follow. The regions that have plenty natural resources are also rich. CLMV countries lag behind, but some parts of Vietnam have become richer than other regions.

Figure 7: GDP per capita (2005)

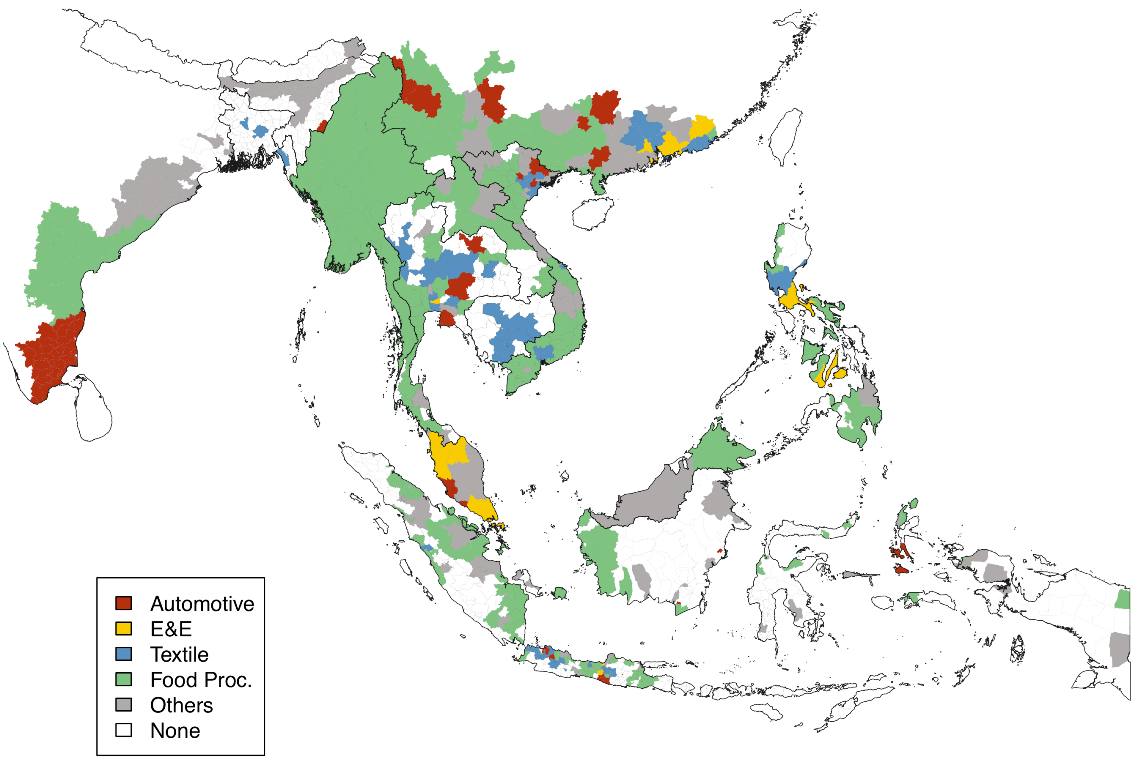


5.3 Industrial Agglomeration

Figure 8 shows the places of industrial agglomeration of the region covered in the simulation. In this paper, we basically try to use the relative importance of each industrial sector within a region. More specifically, we frequently use the Revealed Symmetry Comparative Advantage (RSCA) index to see the relative importance of each industrial sector in each region. RSCA takes the value between -1 to +1. If the share of an industrial sector in a region exactly matches the regional average, RSCA takes 0, which means that the industry in that region has neither advantage nor disadvantage. If the share of an industry in the region is larger than the average, RSCA for the industry takes a positive value and vice versa.

The food sector holds the most advantages in a large number of regions. The category "others" contains various sectors, but resource-based industry is a representative. The textile and garments industry agglomerates in a large part of Cambodia and in some parts of Thailand, Bangladesh, Vietnam, and China. The automotive industry agglomerates in some parts of Thailand and China, in Tamil Nadu of India, and the region around Jakarta in Indonesia, Selangor in Malaysia, and a few regions in northern Vietnam. The E&E industry agglomerates mainly in Singapore and Malaysia, some parts of China, the Philippines, and a few regions in Thailand.

Figure 8: Comparative Advantage in the Manufacturing Sector (2005)



6. Scenarios and Results

6.1 Baseline scenario

Scenario

Some demographic parameters may be held constant and only logistic settings (by scenario) changed. The following macro parameters are then maintained across scenarios:

- The national population of each country is assumed to increase at the rate forecasted by the United Nations Population Fund (UNFPA) until year 2025;
- There is no immigration between the region covered in the simulation and the rest of the world.

The logistic settings follow the specification described in Appendix B. For instance, the average speed of land traffic is set at 38.5 km/h. However, the speed passing through a mountainous area is set at half of it—19.25 km/h.

As for sea traffic, the average speed is set at 14.7 km/h between international-class ports[5], and at half of it among other routes. For air traffic, the average speed is set at 800 km/h between the primary airports[6] of each country and at

[5] In this simulation, we designated the following ports as international-class ports: Port Singapore, Port Madras, Port Hong Kong, Port Saigon, Port Jakarta, Port Manila, Port Laem Chabang, Port Kelang.

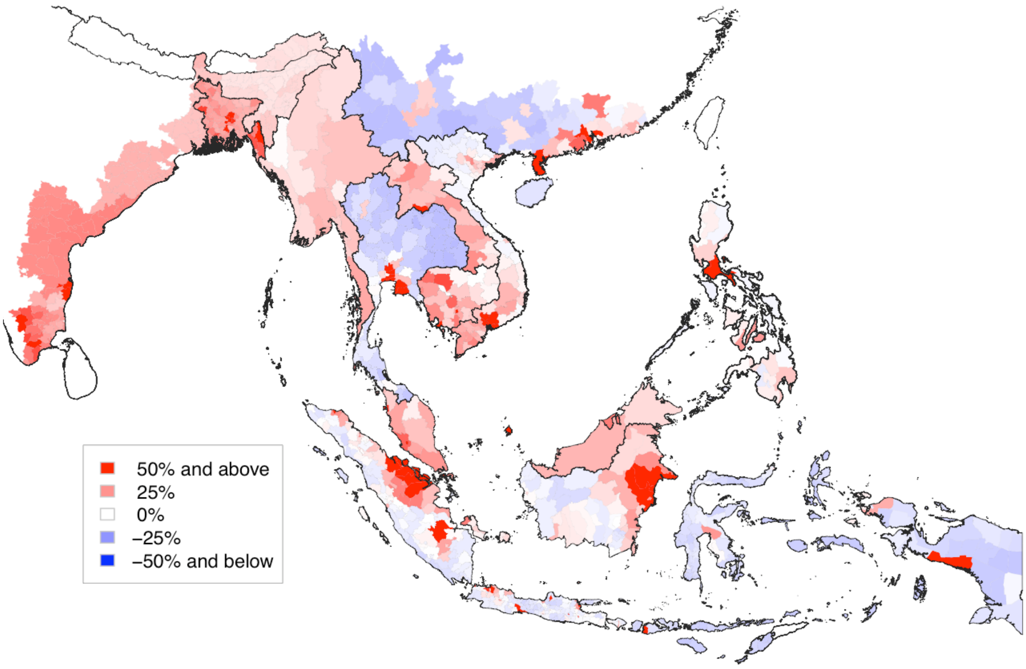
[6] In this simulation, we designated the following airports as primary airports: Brunei Intl Airport, Changi Intl Airport, Hong Kong Intl Airport, Kuala Lumpur Intl Airport, Ninoy Aquino Intl Airport, Soekarno Hatta Intl Airport, Suvarnabhumi Intl Airport, Phnom Penh Intl Airport, Yangon Intl Airport, Wattay Intl Airport, Tansonnhat Intl

400 km/h among other routes.

Population

Figure 9 shows the expected population growth from 2005 to 2020 under the baseline scenario. The countries can be classified into two categories. The first category is the country that evolved a core-periphery structure; the second category is the one that did not. The countries in the former category are China, Thailand, and Indonesia. In China, the population tends to concentrate in some provinces that are located mainly in coastal areas. In Thailand, the population is concentrated in the area near Bangkok. In Indonesia, the population tends to concentrate in some big cities, while the regions mainly have rich natural resources.

Figure 9: Expected Population Growth (2005-2020)

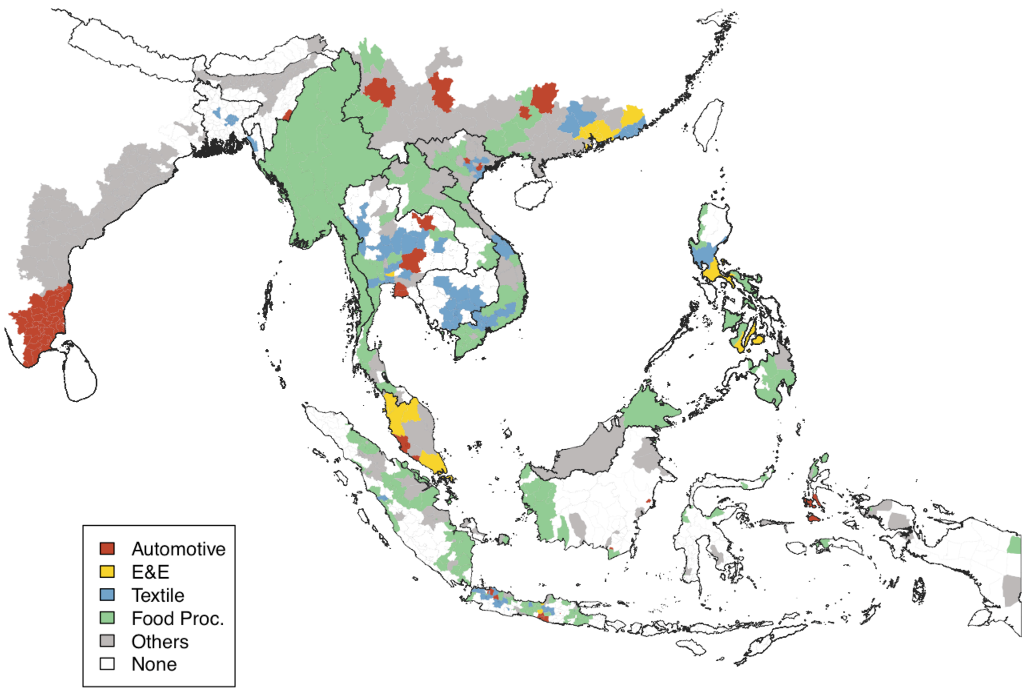


Airport, Chennai Intl Airport, Noibai Intl Airport

Industrial Agglomeration

Figure 10 shows the places of industrial agglomeration, which is represented by comparative advantage index. Basically, the distribution of industries does not change much from 2005 as depicted in Figure 8.

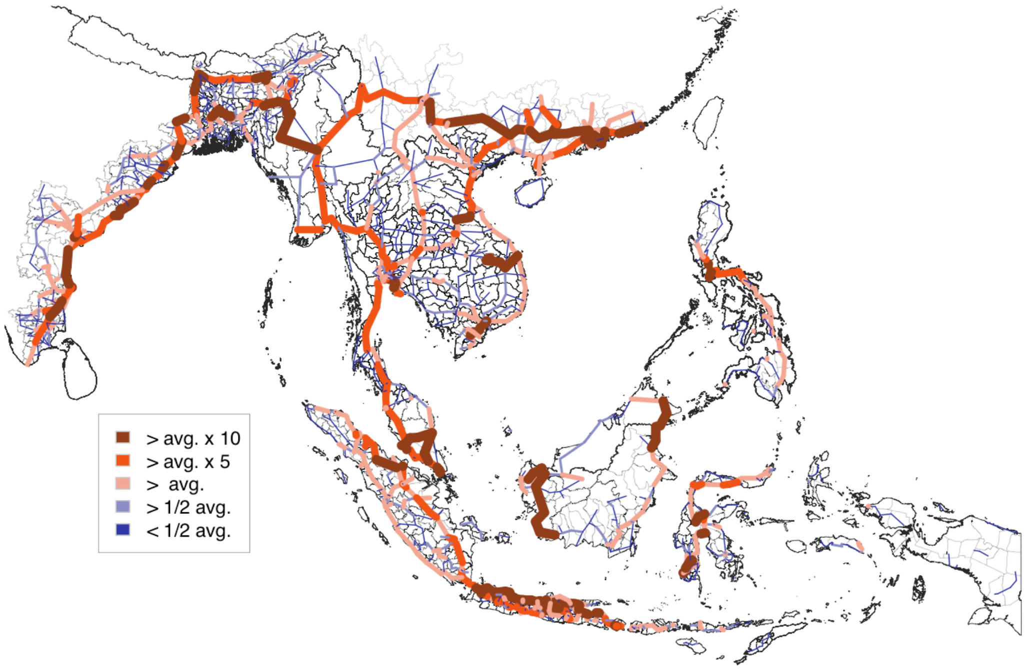
Figure 10: Comparative Advantage in the Manufacturing Sector (2020)



Traffic Volume

Figure 11 shows the expected land traffic volume in 2005. The traffic volume is calculated from the transaction value between any two cities in the region, and the routes used to transport the goods between those two cities. Figure 11 also shows that the traffic volume in the simulation model is relatively orderly, although some differences from reality have been observed.

Figure 11: Expected Land Traffic (2005)



6.2 EWEC

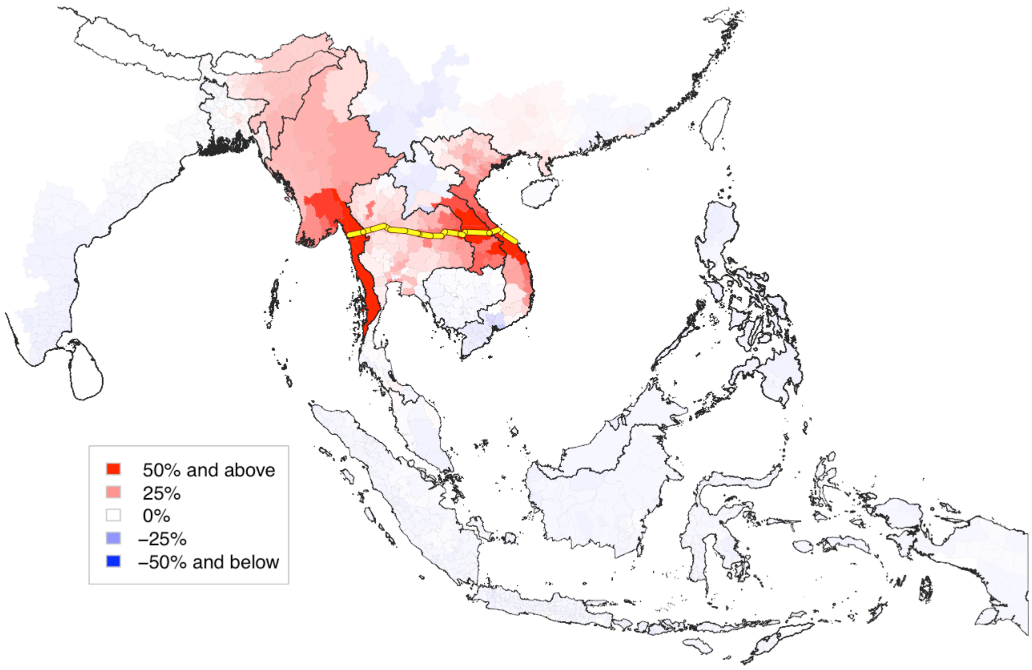
Scenario

First, we checked the effects of customs facilitation along the East-West Economic Corridor (EWEC). Specifically, the overhead time consumed at three borders, i.e., Lao Bao – Densavanh, Mukdahan – Khanthabuly, and Myawadi – Mae Sot is reduced to two hours. In addition to that, the money costs going though these borders are reduced to one-fifth of the baseline scenario.

Economic Effects

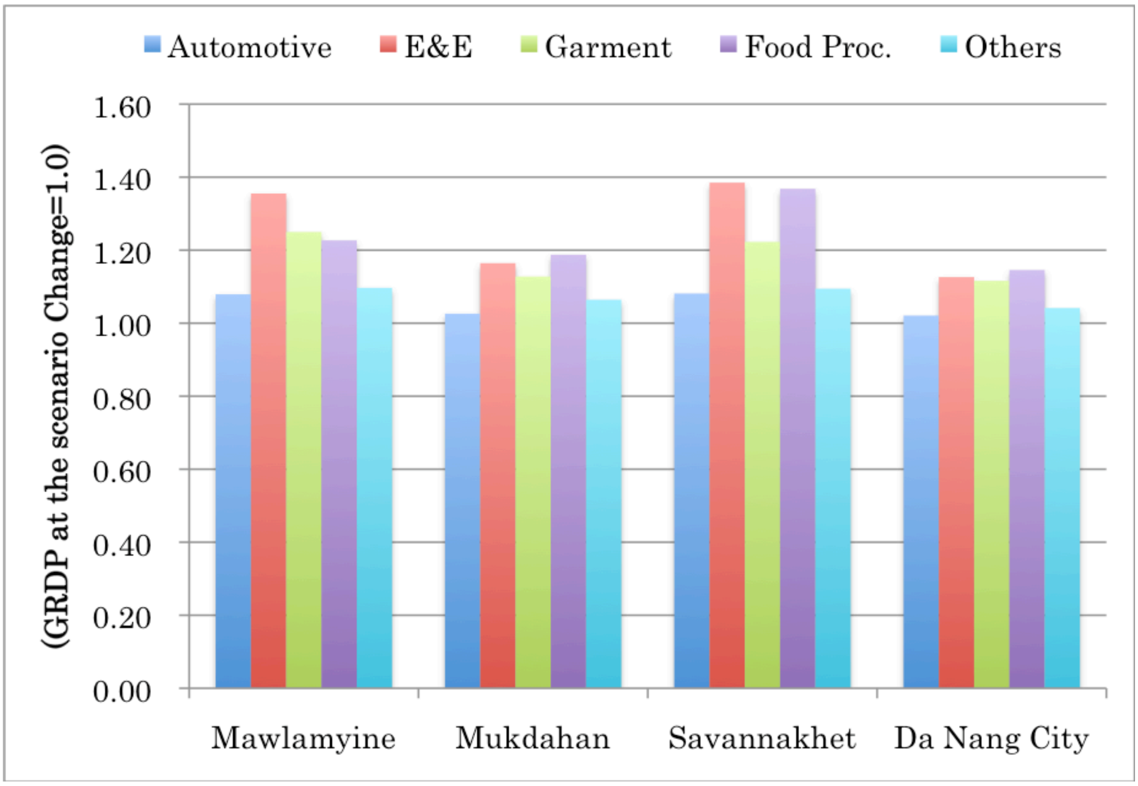
The economic effects of EWEC are depicted in Figure 12. This figure shows the cumulative difference in the regional GDP under EWEC scenario against the GDP under the baseline scenario during the 10 years after the infrastructure development, compared with the expected regional GDP at the scenario change. Generally, the regions along EWEC gain in terms of increased GDP. In particular, some regions in Lao PDR and Myanmar post the cumulative GDP gains of over 50%.

Figure 12: Gains in Regional GDP: EWEC vs. Baseline (10 years cumulative)



The economic effects of EWEC differ by place and industry. Figure 13 deconstructs the economic effects by industry for four cities along EWEC. For instance, the E&E sector in Mawlamyine and Savannakhet gains almost 30%, and the food-processing sector in all four cities gains relatively well. The automotive sector is not changed much by the development of EWEC.

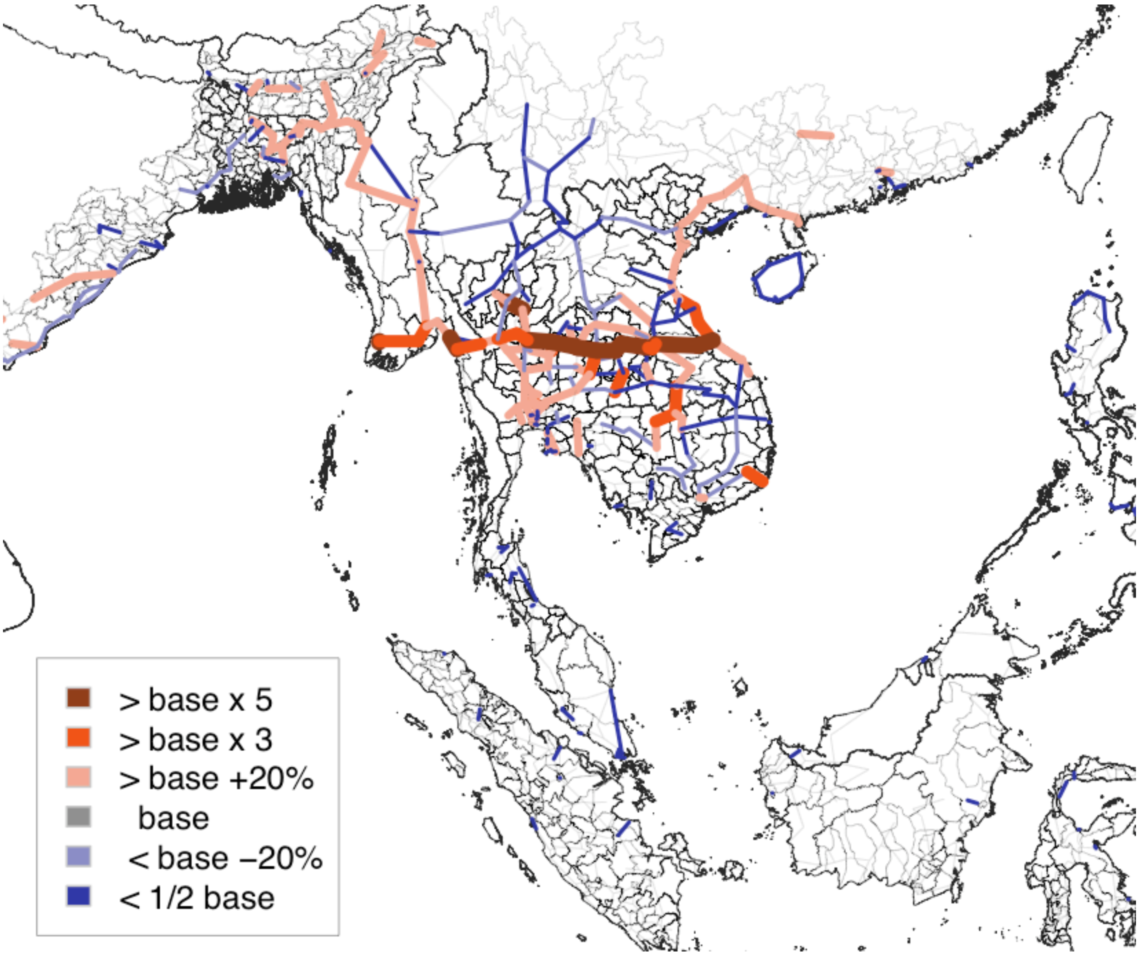
Figure 13: Ecomic Effects of EWEC by Industry (10 years after)



Traffic Volume

The traffic volume changed significantly from the development of EWEC (Figure 14). It appears that the traffic between the eastern and western parts flows into the corridor. In addition to that, the traffic going through EWEC, Bangkok area, and Myanmar is also increasing.

Figure 14: Changes in Traffic Volume EWEC vs. Baseline (10 years after)



The development of EWEC affected sea and air traffic. Tables 2 and 3 show the sea/air routes most affected by EWEC. Table 2 shows that the sea route between Port Madras and Port Laem Chabang has been substituted for by the sea route between Port Madras and Bassein of Myanmar. The port of Da Nang at the east end of EWEC is more utilized[7]. Table 3 shows that the air routes Yangon-Chiang Mai and

[7] Some air/sea routes are currently not in use but included in the simulation at this point. The increasing utilization of some routes is well understood to mean that the routes have high potential.

Yangon-Bangkok have fallen into disuse. It also seems that land routes through EWEC substituted for these two air routes.

Note that the current model of modal choice in IDE/ERIA-GSM selects only one route that minimizes time and money costs for an industry with respect to each origin-destination combination. Thus, the routes that have become relatively costly after the development of an alternative route can fall completely out of use.

Table 2: Sea Routes Most Affected by EWEC (10 years after)

Sea Route			Traffic Change
Port Madras	-	Port Bassein	9.49
Port Manila	-	Port Da Nang	2.32
Port Manila	-	Port Laem Chabang	1.17
Port Jakarta	-	Port Laem Chabang	1.11
Port Laem Chabang	-	Port Singapore	1.11
Port Jakarta	-	Port Madras	0.81
Port Kelang	-	Port Madras	0.61
Port Laem Chabang	-	Port Hong Kong	0.50
Port Chittagong	-	Port Singapore	0.23
Port Madras	-	Port Laem Chabang	0.00

Table 3: Air Routes Most Affected by EWEC (10 years after)

Air Routes			Traffic Change
Danang Intl	-	Changi Intl	1.24
Noibai Intl	-	Hong Kong Intl	1.21
Yangon Intl	-	Netaji Subhash Chandra Bose Intl	1.10
Suvarnabhumi Intl	-	Soekarno Hatta Intl	1.03
Suvarnabhumi Intl	-	Changi Intl	1.01
Yangon Intl	-	Wujiaba	0.58
Wattay Intl	-	Phnom Penh Intl	0.43
Noibai Intl	-	Suvarnabhumi Intl	0.15
Suvarnabhumi Intl	-	Yangon Intl	0.00
Chiang Mai Intl	-	Yangon Intl	0.00

Figures 15 and 16 graphically shows the sea and air routes affected by EWEC.

Figure 15: Sea Routes Most Affected by EWEC (10 years after)

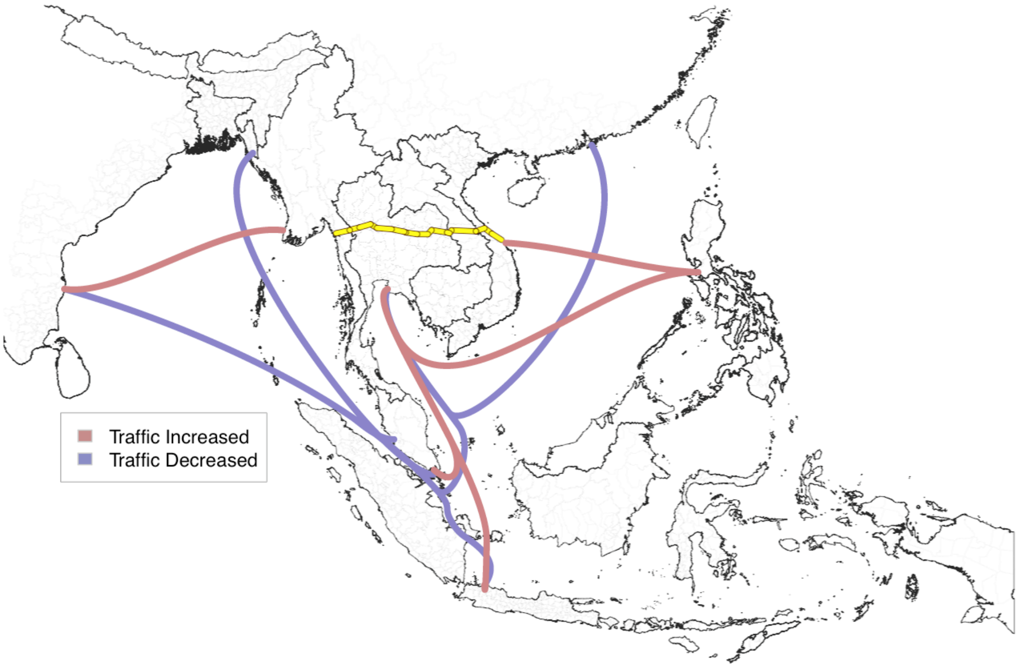
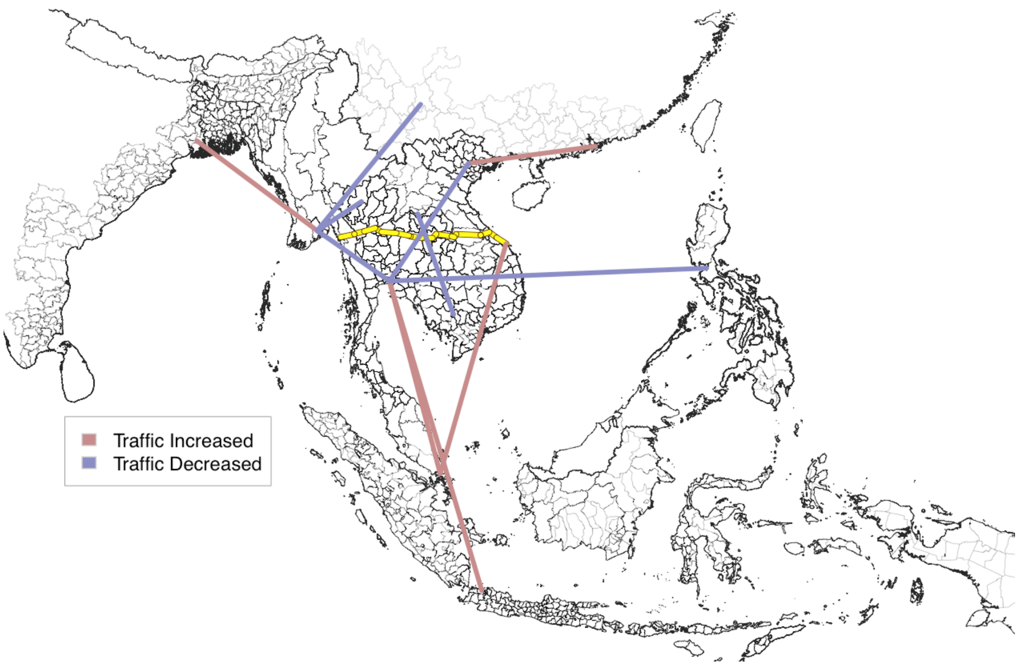


Figure 16: Air Routes Most Affected by EWEC (10 years after)



Modal Shift

Figures 17-1 and 17-2 propose an example of the modal shift. The route between Yangon and Bangkok used by the E&E sector is by air under the baseline scenario. With the development of EWEC, it changes to the land route via a part of EWEC. Before the development of EWEC, time costs consumed at the Myawadi–Mae Sot border was prohibitively high for the E&E industry, making air routes the most reasonable option. After the development of EWEC, land routes seem to be most reasonable choice because of the reduction of wasted time at the Myawadi–Mae Sot border.

Figure 17-1: Route and Mode between Yangon and Bangkok (E&E); Baseline

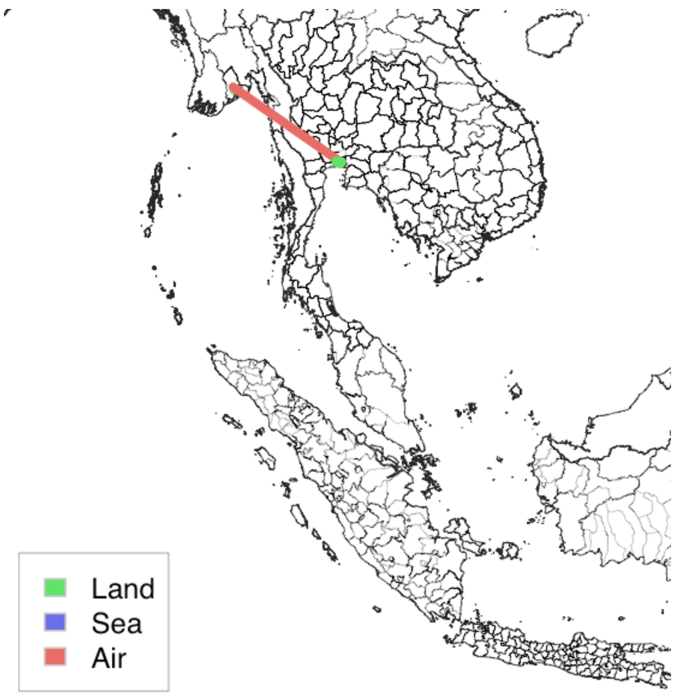


Figure 17-2: Route and Mode between Yangon and Bangkok (E&E); EWEC

6.3 MIEC

Scenario

We checked the effects of the development of the Mekong-India Economic Corridor (MIEC) using three steps. The development is the combination of the construction of the infrastructure, customs facilitation along the corridor, and the establishment of a new sea route between Dawei of Myanmar and Port Madras of India. The three steps are as follows:

- Step 1: The bridge over Mekong River at Neak Loueng is constructed.
- Step 2: Dawei and Kanchanburi of Thailand are connected by road, and

customs facilitation along MIEC is introduced. This reduces the overhead time consumed at three borders (Kanchanburi–Dawei, Ban Khlong Luek–Poipet, and Bavet–Moc Bai) to two hours while the money costs incurred in going through these borders are reduced to one-fifth of the baseline scenario.

- Step 3: We connect Dawei and Port Madras by a sea route that is equivalent to the other routes between internationally important ports[8].

Economic Effects

The economic effects of MIEC, steps 1 to 3, are depicted in Figures 18-1 to 18-3. The figure shows the cumulative difference in the regional GDP under MIEC scenario against the GDP under the baseline scenario after 10 years. At Step 1, the economic effects are limited to the southern half of Cambodia, and the cumulative gains in GDP are merely an order of 1% (Figure 18-1).

At Step 2, the regions along MIEC generally gain higher GDP (Figure 18-2). In particular, all regions in Myanmar and most regions in Cambodia and southern Viet Nam benefit well, and the cumulative gains in GDP are over 50% for some regions.

At Step 3, in addition to the regions along MIEC in the ASEAN, the Indian side also gains some benefits (Figure 18-3).

[8] At first, we connect Dawei and Port Madras by the route equivalent to other local sea routes. In this case, there are no economic effects to the Indian side. This is understood to mean that merely substituting one route for another has very limited economic effects, whereas net improvement of the connection has some economic effects.

Figure 18-1: Gains in Regional GDP: MIEC (Step 1) vs. Baseline (10 years after)

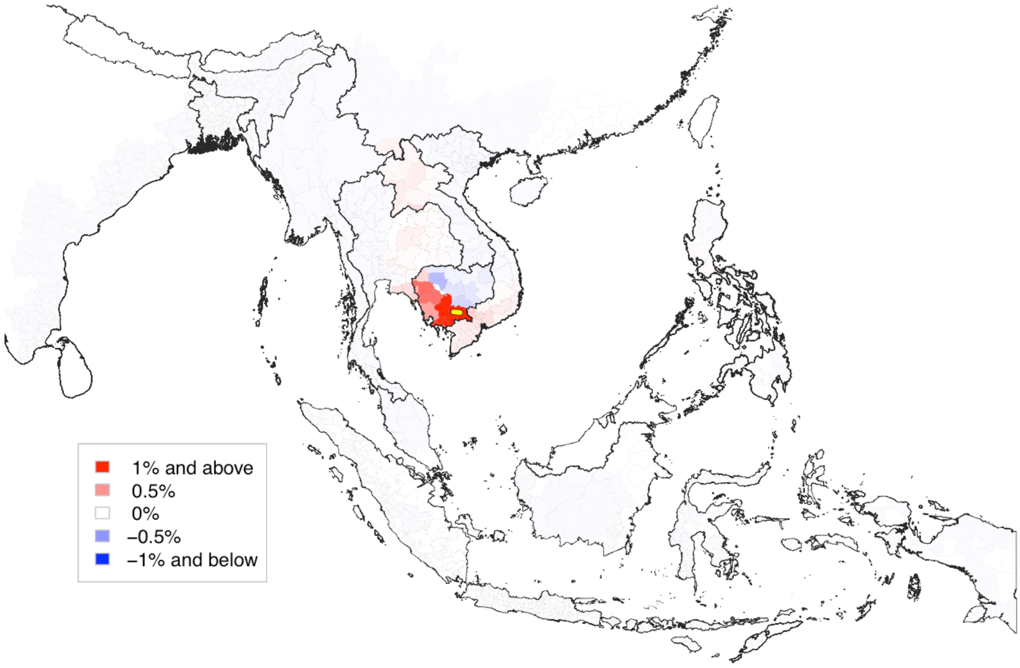


Figure 18-2: Gains in Regional GDP: MIEC (Step 2) vs. Baseline (10 years after)

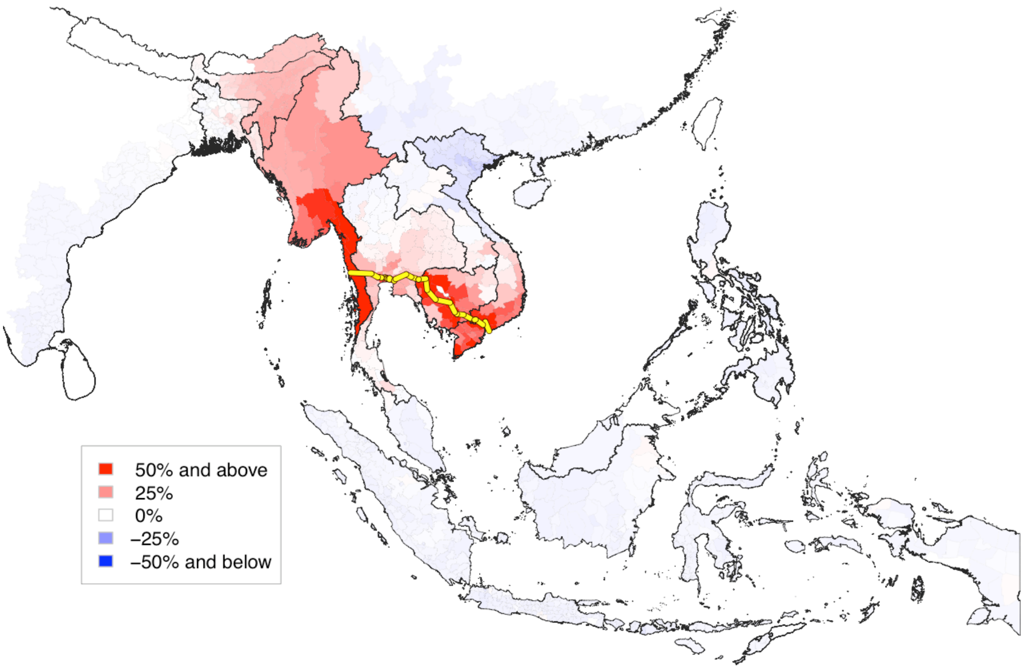
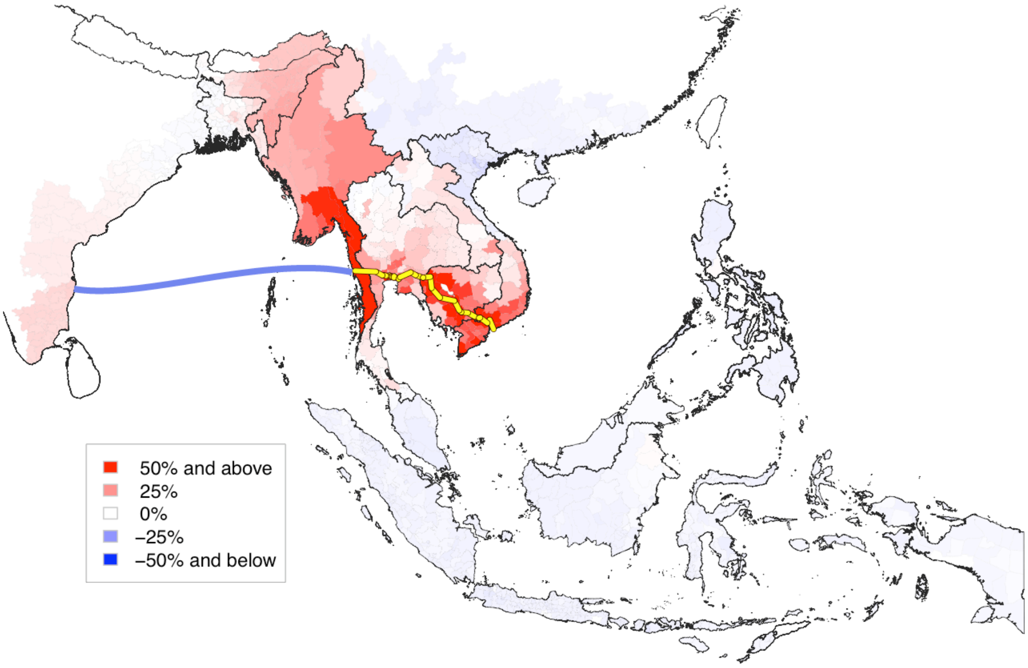
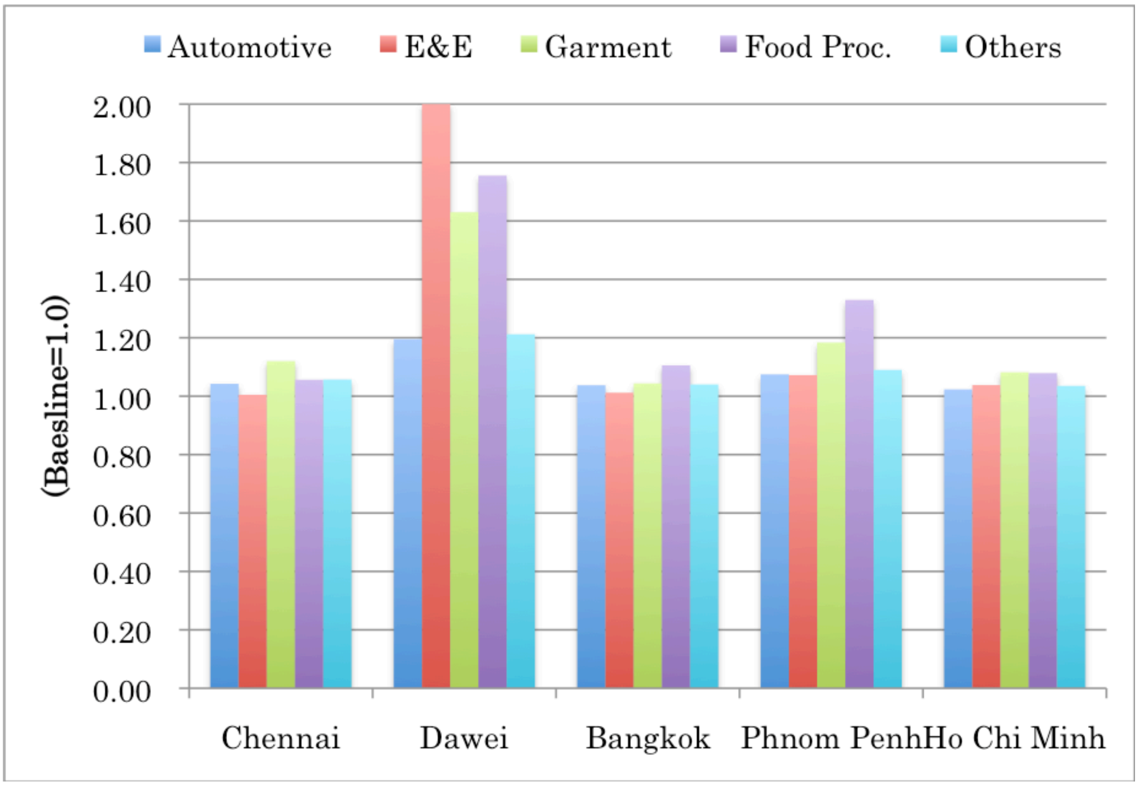


Figure 18-3: Gains in Regional GDP: MIEC (Step 3) vs. Baseline (10 years after)



The economic effects of MIEC also differ by place and industry. Figure 19 deconstructs the economic effects by industry for five cities along MIEC. It is obvious that Dawei, the city that connects the ASEAN and India, benefits the most among the five cities. In particular, the E&E, garments, and food processing industries gain much. The other four cities also benefit, with gains in the food processing industry relatively significant.

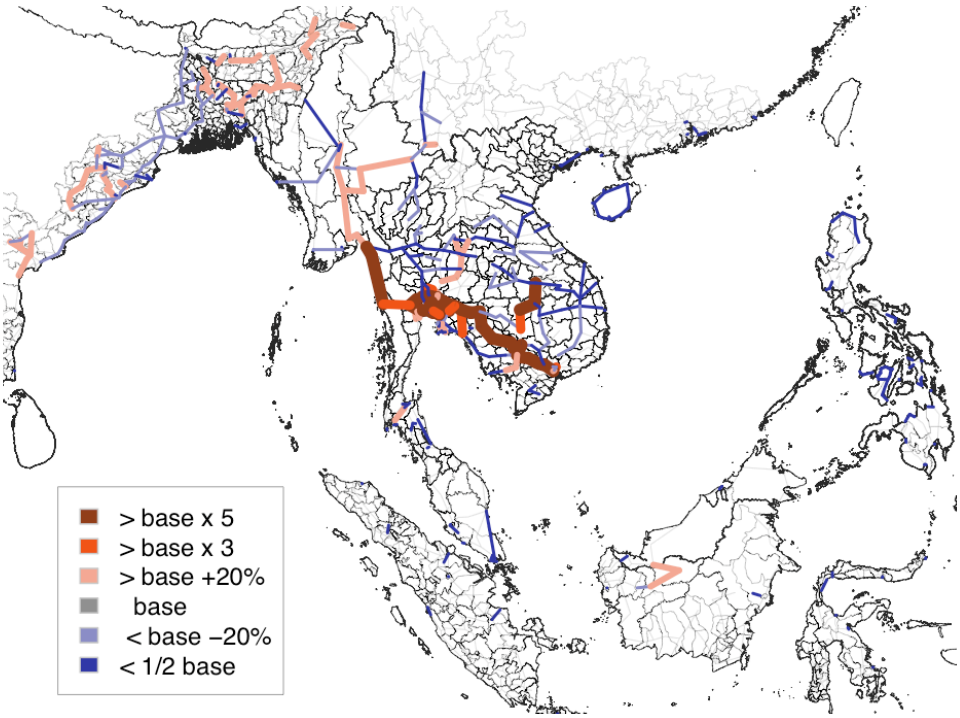
Figure 19: Ecomic Effects of MIEC by Industry (10 years after)



Traffic Volume

Traffic volume changes significantly with the development of MIEC (Figure 20); traffic along MIEC is significantly increasing. On the other hand, other routes connecting the eastern and western parts of the ASEAN generally lose traffic. Some of the routes connecting Myanmar and eastern India and the routes along the east coast of India also lose their traffic. It is easily understandable that the sea routes between Dawei and Port Madras substitute for some traffic between India and the ASEAN.

Figure 20: Changes in Traffic Volume MIEC vs. Baseline (10 years after)



The development of MIEC affects sea and air traffic. Tables 4 and 5 show the sea/air routes most affected by MIEC. Table 4 shows the following modal shifts: (1) Port Saigon, the east end of MIEC, becomes more utilized; (2) the sea routes between Port Madras and the other main ports in ASEAN are substituted for by the newly established sea route, Dawei-Port Madras; (3) Port Laem Chabang-Port Kota Kinabalu seems to be substituted for by Port Saigon-Port Kota Kinabalu and the MIEC route between Ho Chi Minh and Bangkok; (4) the sea route Port Laem Chabang-Port Saigon is substituted for by the land route of MIEC.

Table 4: Sea Routes Most Affected by MIEC (10 years after)

Sea Route			Traffic Change
Port Saigon	-	Port Sorong	5.30
Port Saigon	-	Port Kota Kinabalu	3.17
Port Saigon	-	Port Kuching	3.14
Port Saigon	-	Port Manila	2.58
Port Saigon	-	Port Hong Kong	2.51
Port Madras	-	Port Laem Chabang	0.00
Port Laem Chabang	-	Port Kota Kinabalu	0.00
Port Madras	-	Port Phuket	0.00
Port Madras	-	Port Bassein	0.00
Port Saigon	-	Port Laem Chabang	0.00
Port Saigon	-	Port Madras	0.00

Table 5 shows the following changes: (1) two airports along MIEC, Phnom Penh Airport and Tansonnhat Airport, increase their traffic for some destinations; (2) seven air routes connecting Thailand-Cambodia, Thailand-Myanmar, Thailand-Vietnam, and Vietnam-Cambodia fall into disuse. These routes seem to be substituted for by land traffic on MIEC.

Table 5: Air Routes Most Affected by MIEC (10 years after)

Air Routes			Traffic Change
Phnom Penh Intl	-	Wuxu	11.95
Wattay Intl	-	Phnom Penh Intl	4.64
Tansonnhat Intl	-	Brunei Intl	1.64
Tansonnhat Intl	-	Ninoy Aquino Intl	1.24
Suvarnabhumi Intl	-	Kuala Lumpur Intl	1.07
Suvarnabhumi Intl	-	Penang Intl	0.00
Suvarnabhumi Intl	-	Phnom Penh Intl	0.00
Suvarnabhumi Intl	-	Siem Reap	0.00
Suvarnabhumi Intl	-	Yangon Intl	0.00
Tansonnhat Intl	-	Phnom Penh Intl	0.00
Tansonnhat Intl	-	Siem Reap	0.00
Tansonnhat Intl	-	Suvarnabhumi Intl	0.00

Figures 21 and 22 graphically show the sea and air routes affected by MIEC.

Figure 21: Sea Routes Most Affected by MIEC (2020)

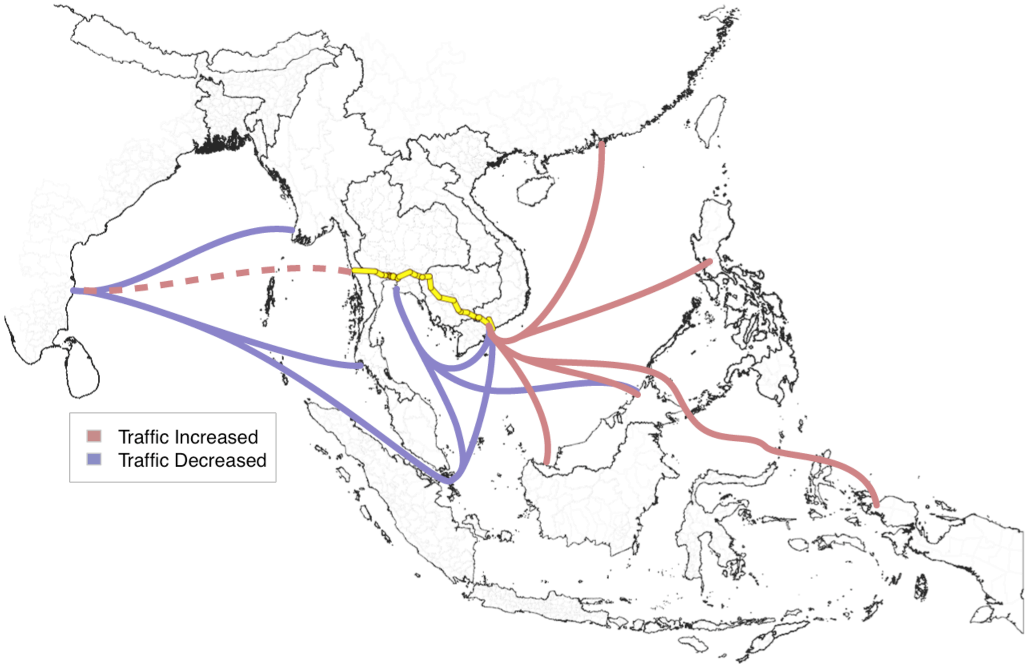
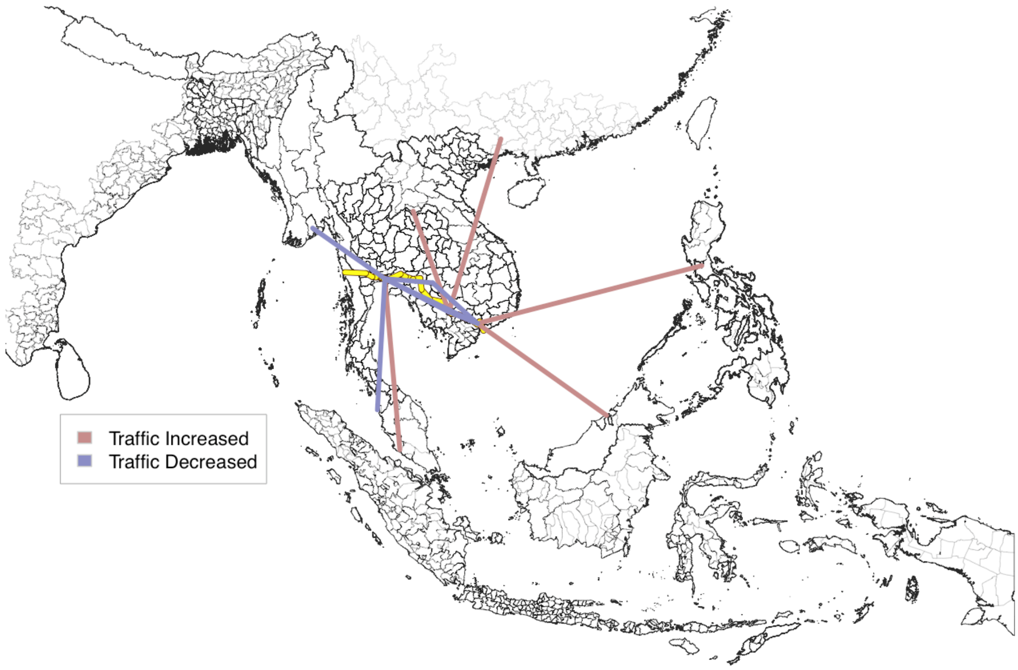


Figure 22: Air Routes Most Affected by MIEC (2020)



Modal Shift

Figures 23-1 and 23-2 propose an example of the modal shift by MIEC. The route between Chennai and Phnom Penh used by the textile and garments sector under the baseline scenario is as follows: sea route between Chennai to Ho Chi Minh, then land route between Ho Chi Minh and Phnom Penh. With the development of MIEC, it changes as follows: sea route between Chennai to Dawei, then land route between Dawei and Ho Chi Minh along MIEC.

Figure 23-1: Route and Mode between Chennai and Phnom Penh (Textile & Garments); Baseline

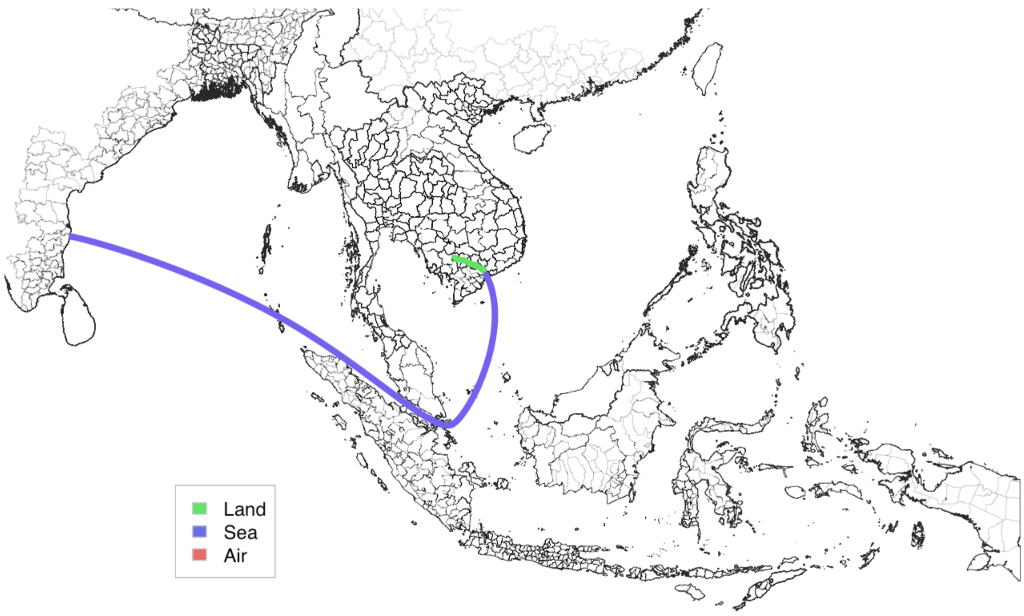
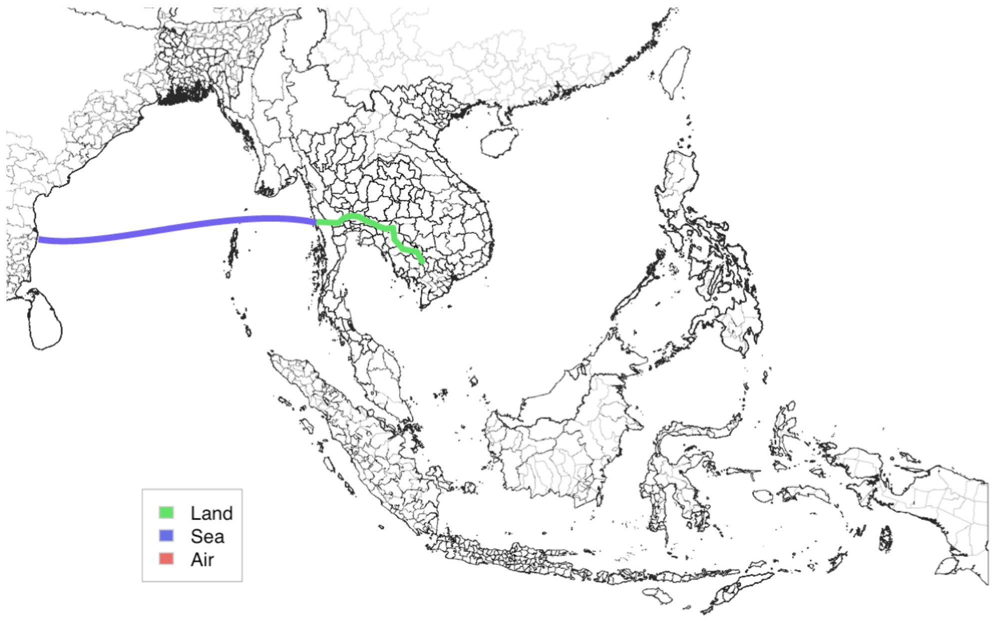


Figure 23-2: Route and Mode between Chennai and Phnom Penh (Textile & Garments); MIEC



6.4 NSEC

Scenario

We checked the effects of customs facilitation along the North-South Economic Corridor (NSEC). Specifically, the overhead time consumed at five borders, i.e., Mohan-Boten, Tachilek-Mae Sai, Chiang Khong-Houayxay, Hekou-Lao Cai, and Mongla-Daluo, is reduced to two hours. The money costs going though these borders are reduced to one-fifth of the baseline scenario. In addition to that, the quality of the road in Myanmar along NSEC is upgraded to the same level as the other NSEC routes.

Economic Effects

The economic effects of NSEC are depicted in Figure 24. The figure shows the cumulative difference in the regional GDP under the NSEC scenario against the GDP under the baseline scenario after 10 years. Generally, the regions along NSEC gain higher GDP. However, strong economic effects like cumulative GDP gains of over 50% are concentrated in the regions near the borders of China, Myanmar, and Lao PDR. On the other hand, the economic effects for southern Thailand are limited.

Figure 24: Gains in Regional GDP: NSEC vs. Baseline (10 years cumulative)

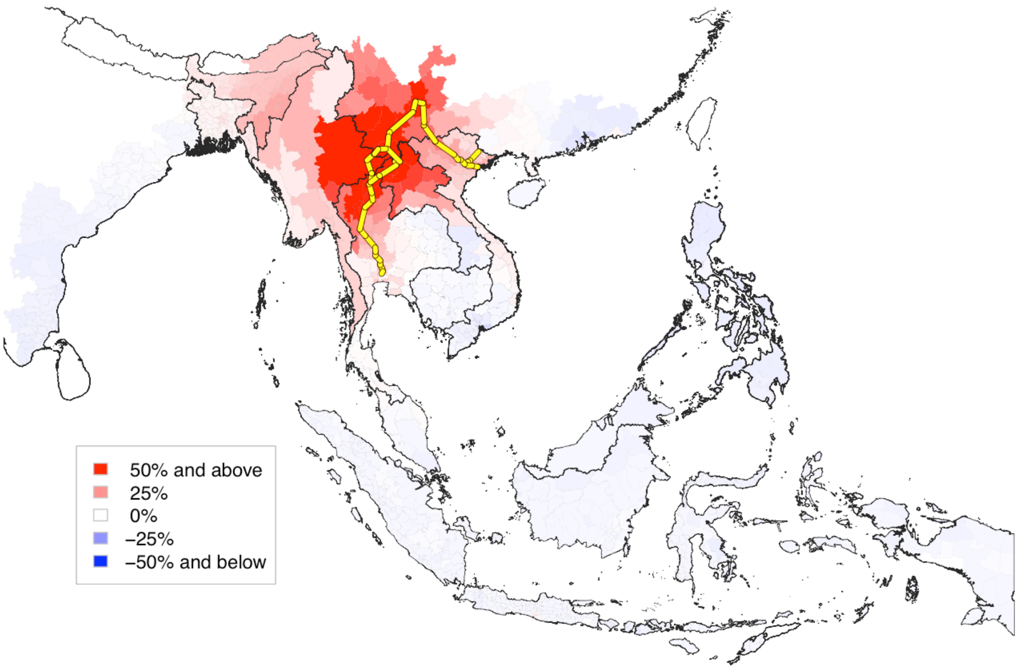
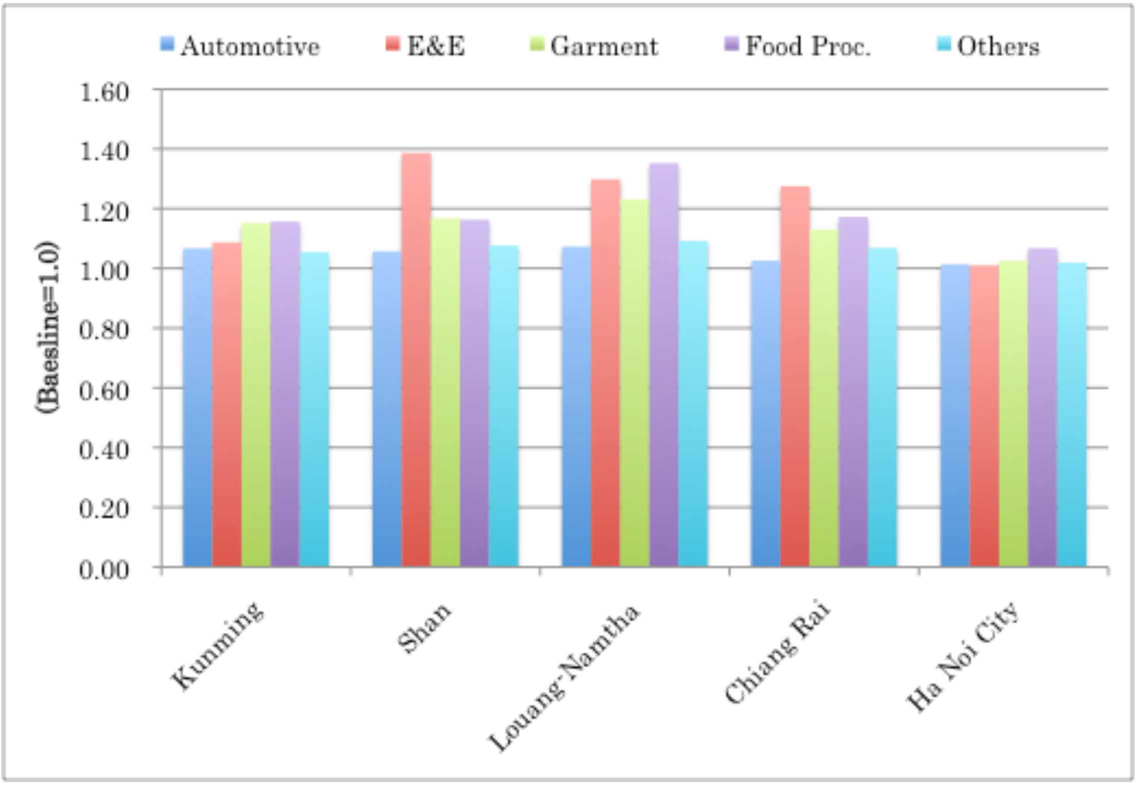


Figure 25 deconstructs the economic effects by industry for five cities along NSEC. The E&E, garment and food processing sectors seem to benefit relatively well.

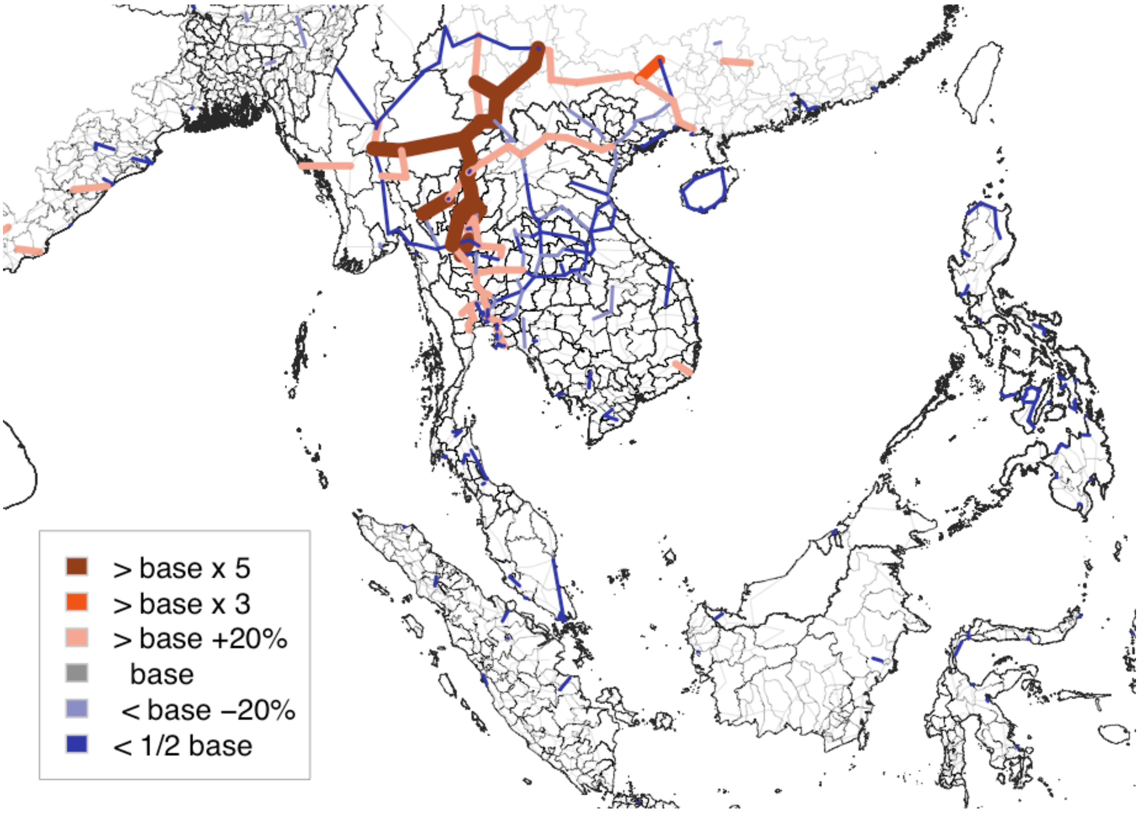
Figure 25: Ecomic Effects of NSEC by Industry (10 years after)



Traffic Volume

Figure 26 shows the changes in traffic volume brought about by the development of NSEC. It indicates that the traffic between the northern and southern regions passing through northern Lao PDR to eastern Thailand shifts to the Myanmar route of NSEC. In addition, the traffic from Yunnan Province of China to the Mandalay region of Myanmar significantly increases. Note that this scenario is based on the assumption that the Myanmar route and Lao PDR route of NSEC are equally developed.

Figure 26: Changes in Traffic Volume NSEC vs. Baseline (10 years after)



The development of NSEC affects sea and air traffic. Table 6 shows that there is no drastic modal shift from sea to land, unlike that caused by the development of EWEC. However, the traffic volume between Port Madras and Port Sittwe increases 1.6 times. This shows that some traffic between India and ASEAN shifts to Port Sittwe and flows into NSEC through Mandalay. The sea route between Leam Chabang and Hong Kong decreases more than 20%, meaning that some sea traffic between Thailand and China flows into NSEC. Table 7 shows that some air route with Wujiaba (Kunmin) and Chaing Mai fall into disuse. It is understood that this air route is substituted for by NSEC. On the other hand, the traffic volume of some air routes between Noibai (Hanoi) and other cities increases. This can be understood to mean that some of the traffic that once passed through Kunming diverges to Noibai airport.

Table 6: Sea Routes Most Affected by NSEC (2020)

Sea Route			Traffic Change
Port Madras	-	Port Sittwe	1.63
Port Saigon	-	Port Kota Kinabalu	1.14
Port Madras	-	Port Bassein	1.12
Port Jakarta	-	Port Laem Chabang	1.08
Port Laem Chabang	-	Port Singapore	1.06
Port Madras	-	Port Laem Chabang	0.93
Port Kota Kinabalu	-	Port Hong Kong	0.92
Port Jakarta	-	Port Saigon	0.90
Port Saigon	-	Port Madras	0.88
Port Laem Chabang	-	Port Hong Kong	0.77

Table 7: Air Routes Most Affected by NSEC (2020)

Air Routes			Traffic Change
Noibai Intl	-	Changi Intl	1.72
Noibai Intl	-	Siem Reap	1.70
Noibai Intl	-	Kuala Lumpur Intl	1.12
Tansonnhat Intl	-	Noibai Intl	1.09
Suvarnabhumi Intl	-	Changi Intl	1.04
Hong Kong Intl	-	Wujiaba	0.00
Wattay Intl	-	Wujiaba	0.00
Changi Intl	-	Wujiaba	0.00
Suvarnabhumi Intl	-	Luang Phabang Intl	0.00
Suvarnabhumi Intl	-	Wujiaba	0.00
Chiang Mai Intl	-	Changi Intl	0.00
Chiang Mai Intl	-	Kuala Lumpur Intl	0.00
Noibai Intl	-	Wujiaba	0.00

Figures 27 and 28 graphically show the sea and air routes affected by NSEC.

Figure 27: Sea Routes Most Affected by NSEC (2020)

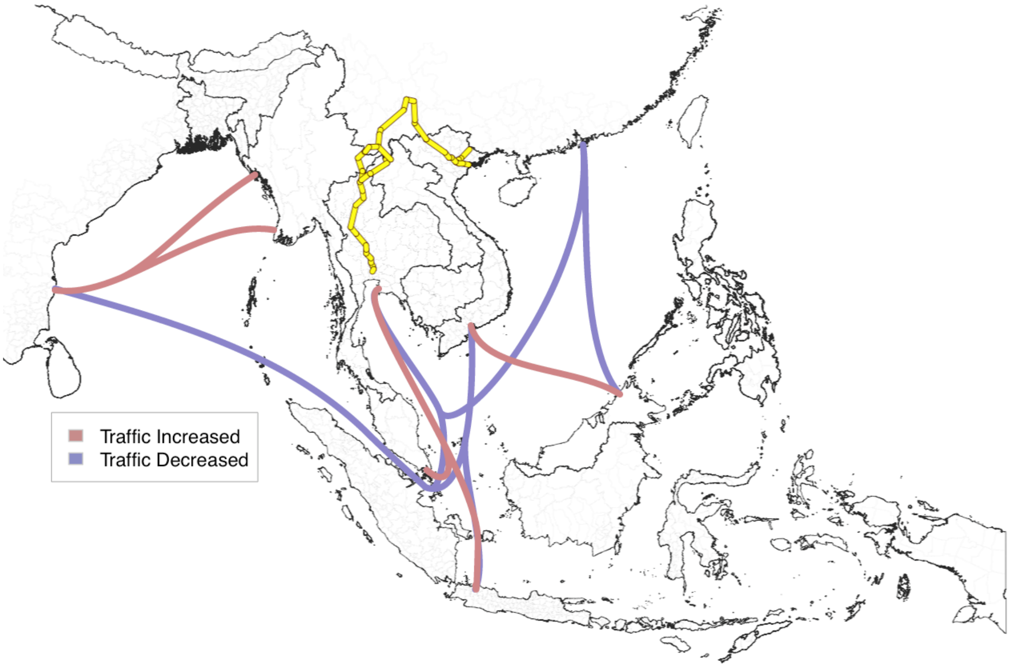
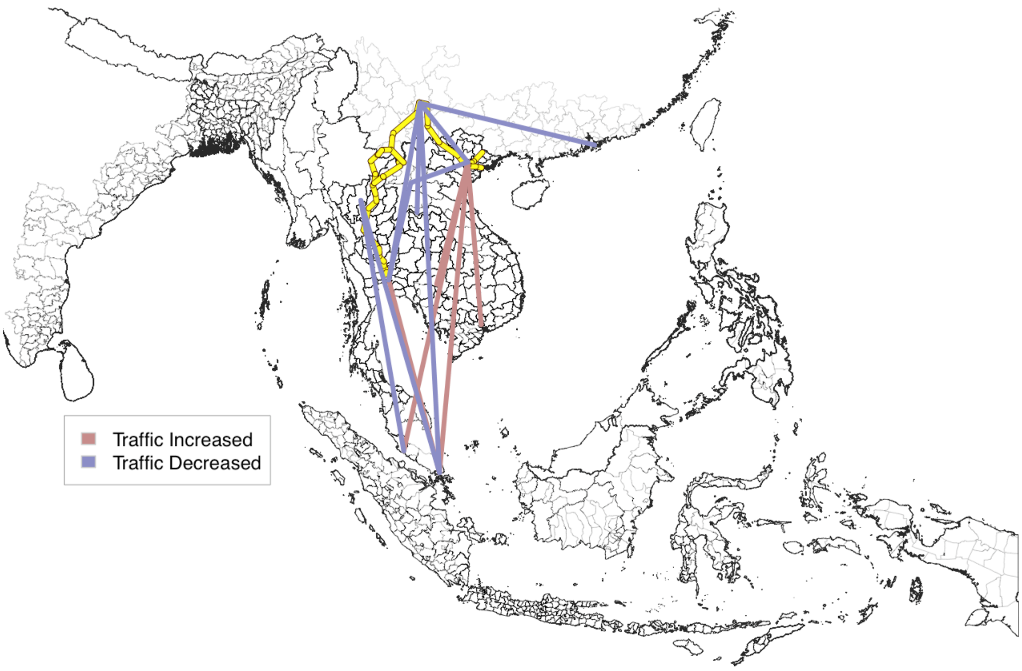


Figure 28: Air Routes Most Affected by NSEC (2020)



Modal Shift

Figures 29-1 and 29-2 propose an example of the modal shift by NSEC. The route between Kuala Lumpur and Kunming used by the food processing sector under the baseline scenario is as follows: land route between Kuala Lumpur to Singapore, sea route between Singapore and Hong Kong, and finally, land route between Hong Kong and Kunming. With the development of NSEC, this route changes to land route between Kuala Lumpur and Kunming through NSEC.

Figure 29-1: Route and Mode between Kuala Lumpur and Kunming (Food Processing); Baseline

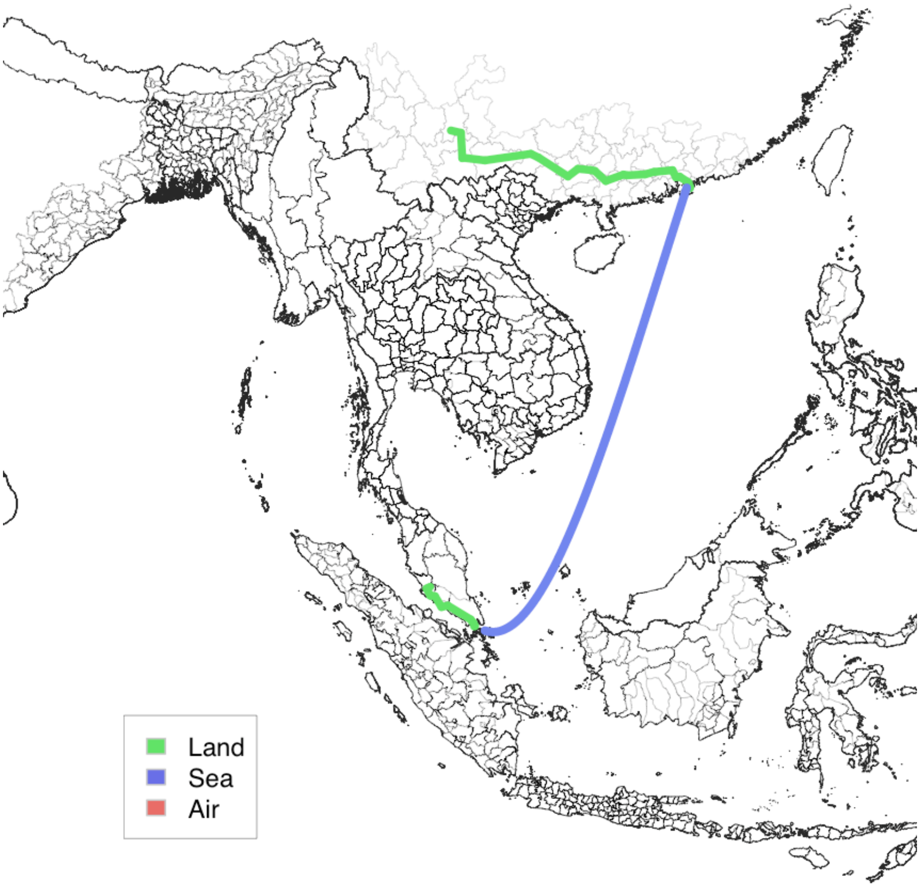
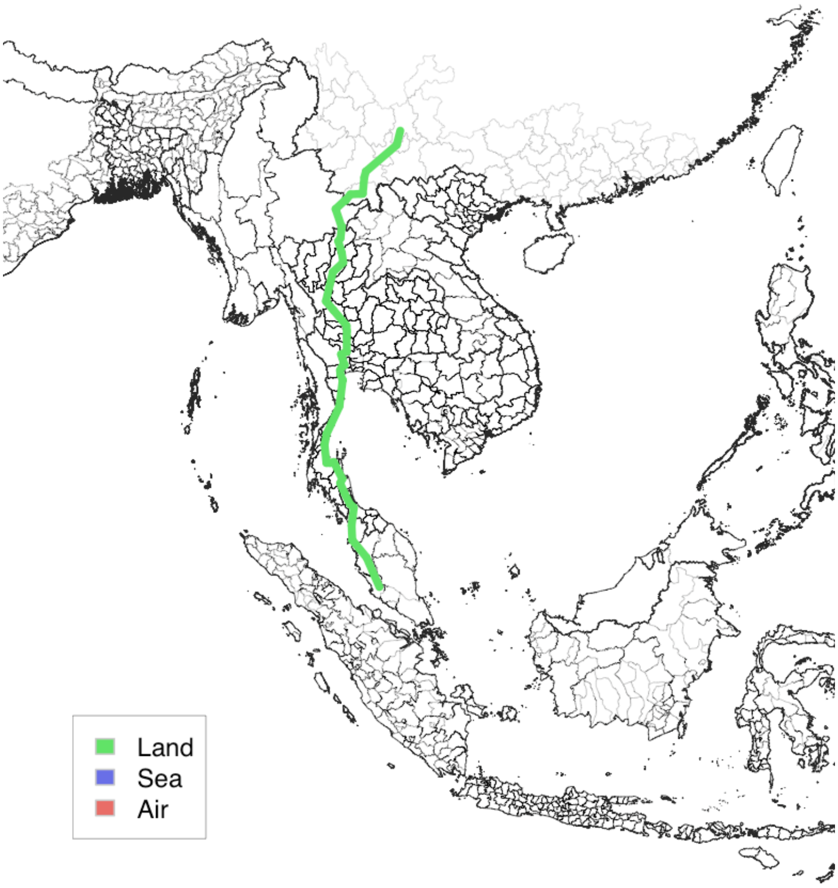


Figure 29-2: Route and Mode between Kuala Lumpur and Kunming (Food Processing); NSEC



6.5 Davao-Manado Sea Route

Scenario

Here we checked the effects of the facilitation of a sea route, Davao-Manado. The sea route between these two cities is upgraded to be on par with the routes between internationally important ports, like Singapore, Jakarta, and Manila. Specifically, the speed going through the routes increases to become twice as fast than the baseline scenario. In addition to that, overhead time spent at the port and the money costs incurred in transshipping are reduced by half.

Economic Effects

The economic effects of the Davao-Manado sea route are depicted in Figure 30. The figure shows the cumulative difference in the regional GDP under the Davao-Manado sea route scenario against the GDP under the baseline scenario after 10 years. The result shows that the GDP in southern Philippines and Sulawesi Island of Indonesia increased.

Figure 30: Gains in Regional GDP: Davao-Manado vs. Baseline (10 years after)

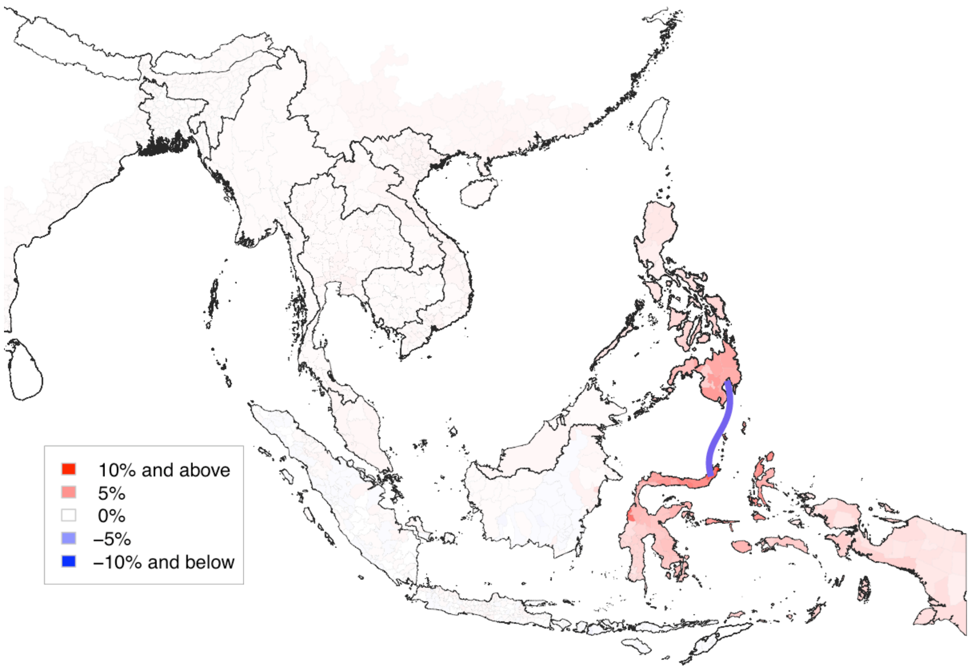
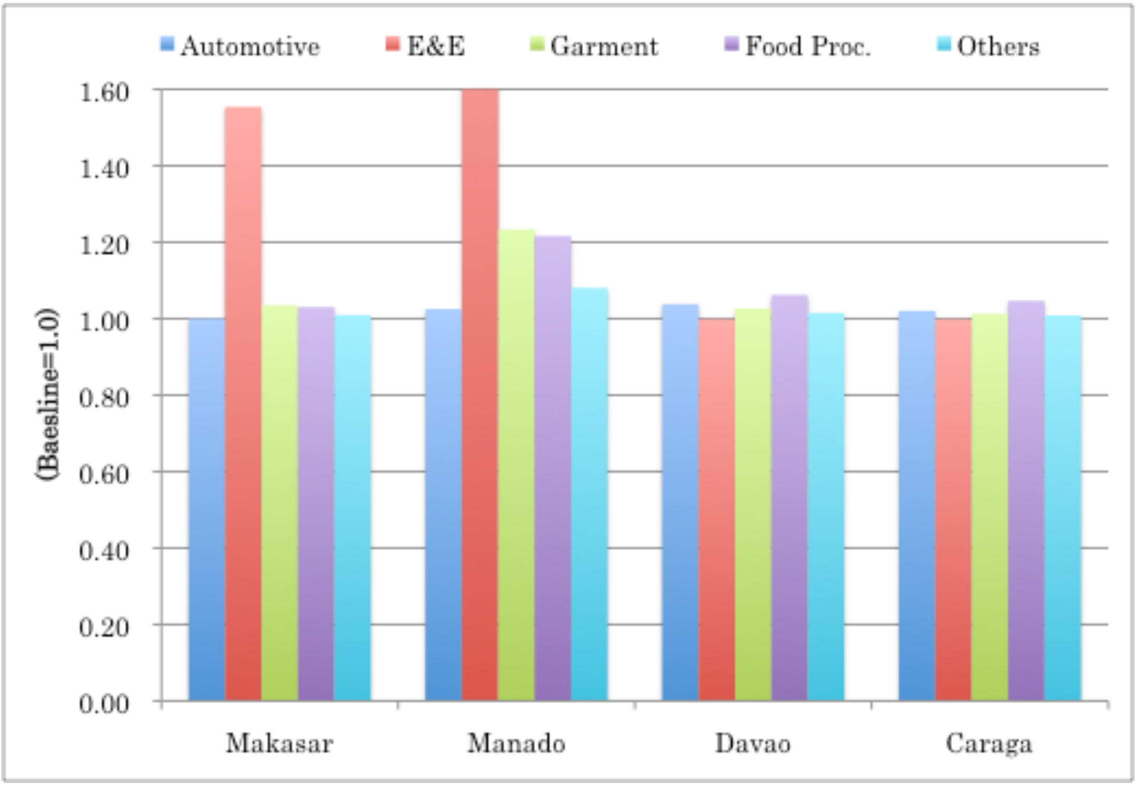


Figure 31 deconstructs the economic effects by industry for four cities near the Davao-Manado sea routes. The E&E sector in Sulawesi Island seems to benefit the most, and the Indonesian side seems to benefit more than the Philippine side.

Figure 31: Economic Effects of Davao-Manado by Industry (10 years after)



The results of additional simulations based on other scenarios are introduced in Appendix E.

7. Conclusion and Policy Recommendations

The third-generation IDE/ERIA-GSM is a cutting-edge economic model that incorporates realistic geography and modal choice. Various analyses show that the economic impacts of logistic infrastructure developments are quite complicated and differ significantly by industry. Therefore, the development should be carefully planned and, for that purpose, an analytical model like IDE/ERIA-GSM has much to contribute.We propose three general policy recommendations.

7.1. Minding the income gap in the developing phase of the economy

The third-generation IDE/ERIA-GSM confirms that infrastructure development will benefit most regions along corridors and near ports and airports. However, large-scale infrastructure development may widen the gaps, i.e., the richer regions may become richer and the poor regions may become poorer. In particular, intranational economic gaps may widen during the phase of economic development, given the restrictions on the mobility of the international labor force.

Thus we should be very cautious when considering regional infrastructure development. The economic improvement of all involved regions is not a given. In addition, infrastructure development might create winning industries and losing industries within a region. The economic effects of infrastructure development are quite complicated and not easily predictable without proper analytical tools. IDE/ERIA-GSM is such a tool and contributes to sound evaluation and prioritization of certain types of planned infrastructure development projects.

7.2. Need to consider modal shift by infrastructure development

The test simulations presented in this paper revealed that an infrastructure development project might lead to quite drastic modal shifts for certain origin-destination combinations. As a result, there is a possibility of under- or overunitization of specific loads/ports/airports.

We thus need to plan infrastructure development projects while considering all modes of transport. In addition to that, the regions affected by an infrastructure development project are often wider than one can imagine. Thus, it is a sensible policy option to establish an international body to coordinate regional transport infrastructure development projects. Again, an economic model with realistic geography and modal choices like IDE/ERIA-GSM has a role to play in predicting possible modal shifts triggered by transport infrastructure development projects.

7.3. Establishment of a geographical economic and social database in East Asia

IDE/ERIA-GSM is a complex system; it is hard to predict without accurate data and a solid simulation model. We need to develop IDE/ERIA-GSM further as well as facilitate the coordination of a geographical statistical system among the member countries of the Economic Research Institute for ASEAN and East Asia (ERIA).

To conduct more accurate simulations with richer implications, more precise regional economic and demographic data are required at the subnational level in each country and at the subprovincial level in China and India. The establishment of uniform territorial units for geographical statistics like the Nomenclature of Territorial Units for Statistics (NUTS) in the European Union (EU) is needed. We need harmonized data as well as harmonized data collection methods in East Asia. ERIA is a suitable body to conduct capacity building for officials in national corridors connecting regions.

We also need more precise data on routes and corridors connecting regions. Information on the main routes between cities, times, and modes of transport (road, railway, sea, and air) appears indispensable. Data on border costs such as tariffs and nontariff barriers due to inefficient customs clearance seem crucial.

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Appendix A: Details of the Model

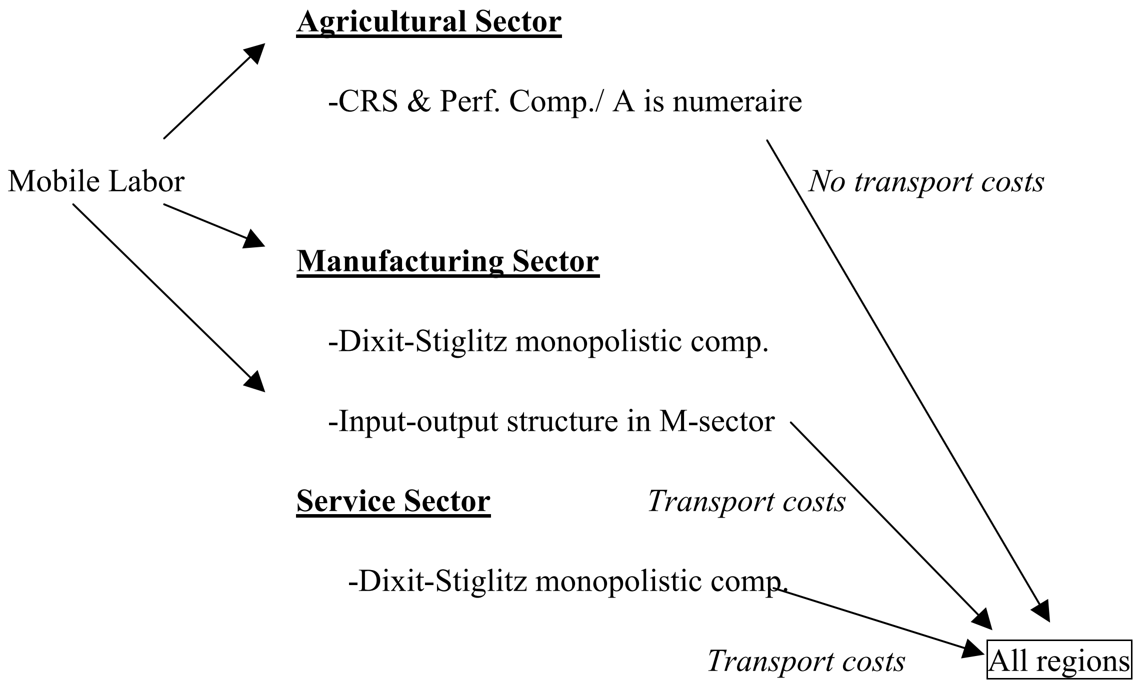
This appendix intends to provide a specific structure for the general equilibrium core-periphery model used in our simulations. The model for our simulations was built by combining the new economic geography models in Fujita, Krugman, and Venables (1999).

A1. The basic structure of our simulation model

In economies, there are 956 locations, indexed by ***r***. The basic structure of the model is shown in Fig. A1. There are two endowments: labor and arable land. Labor is mobile within a country, but immobile among countries as Fig. A1 shows. Arable lands are unequally spread in all regions and owned by all labors of a region.

Everyone in a country is assumed to share the same tastes. Preferences are described by a Cobb-Douglas function of consumption of an agricultural good, a manufactures aggregate, and a services aggregate. Consumption shares of three types of products in the budget of a household differ among countries. The manufactures aggregate is expressed by a constant elasticity of substitution (CES) function of consumption of individual manufactured goods. Likewise, the services aggregate is expressed by the other CES function of consumption of individual services. This pertains to one mass of varieties of manufactured goods and another mass of varieties of services. The expenditure share on an agricultural good is supposed to be so large that an agricultural good is produced in all locations.

Figure A1: Basic Structure of a Model in Simulation



There are three sectors: agriculture, manufacturing, and services. As Figure A1 shows, the agricultural sector produces a single and homogeneous good using a constant-returns technology under conditions of perfect competition in economies. However, manufacturing firms produce differentiated products among a mass of varieties of manufactured goods using an increasing-returns technology under conditions of monopolistic competition. Similarly, differentiated services among the other mass of varieties of services are produced using an increasing-returns technology under conditions of monopolistic competition. The economies of scale arise at the level of variety; there are no economies of scope or of multiplant operations. Since each firm produces or serves one variety, the spread of varieties affects the available size of inputs in each region. Inputs for agricultural products are labor and arable land, inputs for manufactured goods are labor and manufactures aggregate, and input for services consist only of labor. That is, manufacturing firms use input-output structures, but services do not have such structures. Manufactured intermediaries are procured from all manufacturing firms. As for labor, the sectors do not have sector-specific labor; thus, labor moves to the sectors that offer higher nominal wage rates in a region.

All products in three sectors are tradable. Transport costs for an agricultural good are supposed to be costless. Note that the price of an agricultural good is chosen as the numeraire, so the price of the good is one in the economies. Transport costs on manufactured goods and services are supposed to be of the iceberg type. That is, if one unit of product is sent from a location to another location, only some portion of the unit arrives. Depending on the lost portion, the supplier sets a higher price. The increase in price in comparison with the mill price is regarded as transport cost. Transport costs within a region are supposed to be negligible.

A2. The specification of our simulation model

Our simulation model is used to decide twelve values of the following regional variables: nominal wage rates in three sectors; land rent; regional income; regional expenditure on manufactured goods; price index of manufactured goods and of services; 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 dynamics of labors are decided by three differential equations. We start from the specification of equation which decides each variable under a given distribution of labors and then move to the dynamics of labor selection working within a sector in a place.

Nominal wage rates in the agricultural sector is derived from cost minimization in the agricultural sector subject to the production function for the agricultural sector

$$f_A(r) = A_A(r)L_A(r)^{\alpha}F(r)^{1-\alpha}, \tag{A.1}$$

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

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

When used with the production amount, land rent is not used explicitly.

Regional incomes in the NEG model correspond to regional GDPs in our simulations. Supposing that revenues from land at location *r* belong to household at location *r*, GDP at location *r* is expressed as follows:

$$Y(r) = w_M(r)L_M(r) + f_A(r) + w_S(r)L_S(r) \tag{A.3}$$

where $w_M(r)$ and $w_S(r)$ are, respectively, nominal wage rates in the manufacturing sector and the services sector at location *r*, and $L_M(r)$ and $L_S(r)$ are labor input of the manufacturing sector and the services sector at location *r*, respectively.

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

$$E(r) = \mu_M Y(r) + \frac{1-\beta}{\beta} w_M(r) L_M(r) \qquad \text{(A.4)}$$

where μ_M is the consumption share of expenditures on manufactured goods and β is the input share of labor in output. Thus, the first term in (A.4) shows expenditure on manufactured goods, and the last term in (A.4) expresses the expenditure on manufactured goods as intermediary since $1-\beta$ shows the share of intermediary in the output of manufacturing firms.

The price index of manufactured goods at location r is expressed as follows:

$$G_M(r) = \left[\sum_{s=1}^{R} L_M(s) A_M(r)^{\sigma_M - 1} w_M(s)^{(1-\sigma_M)\beta} G_M(s)^{-\sigma_M(1-\beta)} T_{rs}^{M\,-(\sigma_M - 1)}\right]^{\frac{1}{-(\sigma_M - 1)}}, \text{(A.5)}$$

where T_{rs}^{M} is the iceberg transport costs from location r to another location s for manufactured goods and σ_M is the elasticity of substitution between any two differentiated manufactured goods. To derive (A.5), we substitute the price of manufactured goods and the number of varieties into the minimum cost of purchasing a unit of manufactures aggregate. Manufacturing firms at location r produce using the composite of labor and manufactures aggregate. The technology on the composite requirements is the same for all varieties and in all locations and is expressed as a linear function of production quantity with a fixed input requirement. The price of manufactured goods is set as $p_M(r) = w_M(r)^{\beta} G_M(r)^{1-\beta} / A_M(r)$ where $w_M(r)$ is the nominal wage of the manufacturing sector at location *r*, and $G_M(r)$ is the price index of manufactured goods at location *r*. Here, the marginal input requirement is supposed to equal the price-cost markup. The supply of a variety is decided by the zero-profit condition. The quantity of supply depends on the size of the fixed input requirement. Using the supply of manufactured goods and choosing the size of the fixed input requirement adequately, the number of manufacturing firms at a location is decided using the relation between the share β of labor input and the demand for manufactured goods. As a first step, the price index of manufactured goods is derived from the expenditure minimization of a constant-elasticity-of-substitution function.

The price index of services at location *r* is expressed as follows:

$$G_S(r) = \left[\sum_{s=1}^{R} L_S(s) A_S(r)^{\sigma_S - 1} w_S(s)^{-(\sigma_S - 1)} T_{rs}^{S-(\sigma_S - 1)} \right]^{\frac{1}{-(\sigma_S - 1)}} \qquad \text{(A.6)}$$

where T_{rs}^S is the iceberg transport costs from location *r* to another location *s* for services, σ_S is the elasticity of substitution between any two differentiated services. We choose the production units by a firm that equals to the inverse of the consumption share of services. The derivation processes are slightly different. Using only labor, the technology is the same for all varieties and in all locations and is expressed as a linear function of production quantity with a fixed input requirement. The price of services is set as $p_S(r) = w_S(r)/A_S(r)$ where $w_S(r)$ is the nominal wage of the service sector at location *r* and $A_S(r)$ is the production efficiency of the service sector at location *r*. The number of varieties of services is decided from the equality of wage payment and the expenditure share of labor at location *r*.

Nominal wages in the manufacturing sector at location *r* at which firms in each location break even is expressed as follows:

$$w_M(r) = \left[\frac{A_M(r)\beta^{\frac{1}{\sigma_M}} \left[\sum_{s=1}^{R} E(s) T_{rs}^{M\,1-\sigma_M} G_M(s)^{-(1-\sigma_M)} \right]^{\frac{1}{\sigma_M}}}{G_M(r)^{1-\beta}} \right]^{\frac{1}{\beta}}, \tag{A.7}$$

using the equality of demand and supply on a variety of manufactured goods. Similarly, nominal wages in the service sector at location *r* are expressed as follows:

$$w_S(r) = A_S(r) \left[\sum_{s=1}^{R} Y(r) T_{rs}^{S\,1-\sigma_S} G_S(s)^{-(1-\sigma_S)} \right]^{\frac{1}{\sigma_S}}. \tag{A.8}$$

From (A.1) to (A.8), the variables are decided using a given configuration of labor. Derived regional GDP, nominal wage rates, and price indexes are used to determine labor's decision on a working sector and place. The dynamics for labor to decide on a specific sector within a location is expressed as follows:

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

where $\dot{\lambda}_I(r)$ is the change in labor (population) share for a sector within a location γ_I is the parameter used to determine the speed of job change within a location, $\omega_I(r)$ is the real wage rate of any sector at location *r*, and $\overline{\omega}(r)$ is the average real wage rate at location ***r***. The population share for a sector within a country is expressed as follows:

$\lambda_I(r) = \dfrac{L_I(r)}{L_A(r) + L_M(r) + L_S(r)}$. The dynamics of labor migration in a country is expressed as follows:

$$\dot{\lambda}_L(r) = \gamma_L \left(\frac{\omega(r)}{\overline{\omega}_C} - 1 \right) \lambda_L(r) \tag{A.10}$$

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

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

where ν shows the consumption share of services. Furthermore, $\overline{\omega_C}$ in (A.10) shows the average real wage rate at location *r*.

Notice that labor migration is affected by per capita regional GDP and price index.

Using two dynamics, (A.9) and (A.10), we decided the spread of labors among locations and the selection of sector in a location.

APPENDIX B: Transport Costs

This appendix explains how transport costs between regions are calculated. We first specify firms' behavior in shipping their products and estimate the multinomial logit model on it by using firm-level data. Next, we estimate some parameters such as holding time across borders. By employing those estimates in addition to the multinomial logit results, transport costs T are calculated.

B1. Firm-level Transportation Modal Choice

In this section, we calculate the geographical distance between trading partners in which transportation modes such as air and sea become indifferent to each other in terms of their chosen probability. The next subsection summarizes the mechanics of firms' modal choice by developing a simple theoretical model. Based on the model, Section B1.2 specifies the empirical equation to investigate firms' modal choice, of which estimation results are reported in Section B1.3.

B1.1. Theoretical Framework

We develop a model in which firms choose a transportation mode from among the three modes: air, sea, and truck. Our model specifies the probability that a mode yields the highest profits for a particular firm. We choose functional forms to obtain a final specification that is linear in parameters.

The firm manufactures a unique variety with log demand curve $\ln x_{ji} = \ln A_i - \eta \ln p_{ji}$, where $p_j = p_{ji}\, t_{ji}$. The variable p_j is the price of the variety produced in country j, and A_i is the income of consumers of the varieties in country i. The variable x_{ji} denotes the demand of country i for the variety produced in country j while η is the elasticity of substitution between varieties and is assumed to be greater than unity. The variable t_{ji} represents transportation time between countries i and j (expressed in tariff equivalent) rather than the standard trade costs and captures the depreciation of goods, which occurs because the characteristics of goods that consumers desire change randomly over time.

The market structure is assumed to be Chamberlinian monopolistic competition. The producer of each country inputs labor and pays shipping costs. The shipping costs are assumed to be a function of transportation time. Notice that, strictly speaking, the shipping costs here are specified to be simpler compared with the ones above (e.g., τ_{ij}). Furthermore, the transportation time is also specified to be different from $Time_{ij}$. In short, the transport cost structure of the model in this section is simplified so as to be able to easily estimate the model.

Specifically, the cost function is assumed to be:

$$C\left(x_{ji}\right) = w_j^{\theta_w} t_{ji}^{\theta_M} x_{ji} + f_j,\ \theta_w > 0,\ \theta_M > 0,$$

where w_j and f_j denote wages and fixed costs, respectively. The parameter θ_M is a parameter for transportation time and plays a role in transforming the time to the total transportation charge. Its magnitude depends on the mode M: $\theta_{Air} > \theta_{Truck} > \theta_{Sea}$.

We assume that in the short run, firms can change only the quantity of production, not transportation mode. Each firm maximizes its profit with respect to quantity to derive producer prices:

$$p_j = \left(\frac{\eta}{\eta - 1}\right) w_j^{\theta_w} t_{ji}^{\theta_M}.$$

As a result, we can derive a profit function from supplying products from country *j* to country *i*:

$$\pi_{ji} = kA_i w_j^{-\theta_w(\eta-1)} t_{ji}^{-[(\theta_M+1)(\eta-1)+1]} - f_j, \quad k \equiv \eta^{-\eta}(\eta-1)^{1-\eta}. \tag{B.1}$$

We assume that transportation time can simply be specified as:

$$\ln\ t_{ji} = \lambda_M\ \ln\ d_{ji}, \tag{B.2}$$

where λ_M is a parameter that transforms distance (d_{ji}) into transportation time and is mode specific: $\lambda_{Sea} > \lambda_{Truck} > \lambda_{Air}$. Substituting equation (B.2) into the log version of equation (B.1), we obtain:

$$\ln\left(\pi_{ji}^M + f_j\right) = \ln k + \ln A_i - (\eta - 1)\theta_w \ln w_j - \left[(\eta - 1)\left(\theta_M + 1\right) + 1\right]\lambda_M \ln d_{ji},$$

Only mode-specific variables affect the profit ordering of modes. We define U_M as:

$$U_M \equiv \ln\left(\pi_{ji}^M + f_j\right) - \ln k - \ln A_i + (\eta - 1)\theta_w \ln w_j = -\left[(\eta - 1)\left(\theta_M + 1\right) + 1\right]\lambda_M \ln d_{ji}. \tag{B.3}$$

The firm chooses a mode with the highest U_M among air, sea, and truck. In other words, given the elasticity, a mode with the lower λ_M and/or the lower θ_M is chosen in shipping varieties.

B1.2. Empirical Issues

We empirically investigate the determinants of firms' transport mode. To do that, we estimate equation (B.3) after some modification. First, our parameters, particularly η and θ_M, obviously differ among industries. For example, machinery parts are small and light, so that firms producing them have a relatively low θ_{Air} and thus a small difference between θ_{Air} and θ_{Sea}. Therefore, if λ_M is not so different among industries, air transportation is more likely to be chosen in shipping machinery parts because θ_M becomes a crucial element for firms' choice of a mode. These differences among industries are controlled by introducing the intercepts of industry dummy variables (u_s) with distance variable. Second, the level of port infrastructure is obviously different among countries. Its difference yields different λ_M and θ_M among modes in each country. To control such differences among countries in which reporting firms locate, we introduce country dummy variables (v_k). Last, qualitative differences between intra- and international transactions are controlled by introducing a binary variable (*Abroad*), taking unity if transactions are international ones and zero otherwise.

Based on this modification, we redefine our profit function as:

$$V_M \equiv U_M + \varepsilon_M = \alpha \cdot Abroad_{ji} + \sum_s \beta_s^M u_s \ln d_{ji} + \sum_k \gamma_k^M v_k + \varepsilon_M \,, \qquad \text{(B.4)}$$

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

$$\Pr\left(Y_i = M \mid Abroad_{ji}, \ln d_{ji}\right) = \frac{e^{U_M}}{1 + e^{U_{Air}} + e^{U_{Truck}} + e^{U_{Sea}}} \text{ for M = Air, Sea, Truck.} \qquad \text{(B.5)}$$

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.

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. The four countries covered in the survey were Indonesia, the Philippines, Thailand, and Vietnam. The sample population is restricted to selected manufacturing hubs in each country (JABODETABEK area, i.e., Jakarta, Bogor, Depok, Tangerang, and Bekasi, for Indonesia; CALABARZON area, i.e., Cavite, Laguna, Batangas, Rizal, and Quezon, for the Philippines; Greater Bangkok area for Thailand; and Hanoi area and Ho Chi Minh City for Vietnam). This dataset includes information on transport mode that each firm chose in supplying its main product and sourcing its main intermediate inputs. From there, the products' origin and destination can be also identified. In our analysis, however, the combination between origin and destination is restricted to one accessible by land transportation in order to assure consistency with our theoretical framework.

B1.3. Empirical Results

We take a brief look at firms' choice of transportation mode. Table 1 reports the combination of trading partners in our dataset. There are three noteworthy points here. First, as mentioned above, firms in the Philippines and Indonesia are restricted to the ones with intranational transactions, although most of the firms in the other countries in our dataset are also engaged in the intranational transactions. Second, there is a relatively large number of Vietnamese firms trading with China. Third, Table B2 shows the transportation mode by location of firms, indicating that most of our sample firms tend to choose truck. Intuitively, this may be consistent with the first fact that most of the firms trade domestically.

Table B1. The 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

Table B2. 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

The MNL result is provided in Table B3. Three points are noteworthy. First, in trading with partners abroad, firms are likely to choose air or sea. Second, 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 product of λ_M and θ_M is lower in air and sea than in truck. Third, the intercept term of distance in machinery industries has a significantly positive coefficient in air. As mentioned before, not only the elasticity but also θ_M are different among industries. As is consistent with our expectation, our result may indicate the lower value of θ_{Air} in machinery industries.

Table B3. 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 : show 1%, 5%, and 10% significance, respectively.

Last, we conduct some simulations to get a more intuitive picture on the transportation modal choice. Specifically, employing our estimators, we calculate the distance between trading partners in which the two transportation modes become indifferent in terms of their probability. For example, suppose that a firm in the food industry in Bangkok trades with a partner located in a 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. In the calculation, we set *Abroad* to the value of one, i.e., international transactions. The results are reported in Table B4. In Bangkok, for example, firms in machinery industries 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 use only truck.

Table B4. Probability Equivalent Distance with Truck (Kilometer): 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

B2. The Calculation of Transport Costs

In this section, we calculate the transport costs by using the estimates and the logit results in the previous section. To this end, several parameters are necessary, some of which are estimated in Section B2.1.

B2.1. The Estimation of Speed and Holding Time

Our strategy for estimating transportation speed and holding time is very straightforward and simple. Specifically, 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 ρ_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. In other words, for example, the estimation here includes transactions between Indonesia and Thailand.

The OLS regression results are reported in Table B5. Although some of the holding time coefficients, i.e., ρ_0^M and ρ_1^M, are insignificantly estimated, their magnitude is reasonable enough. As for the distance coefficient, its magnitude in sea and truck is reasonable, but that in 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 airport. This will underestimate the air transportation speed.

Table B5. Results of OLS Regression: Holding Time and Transportation Speed

	Air	Sea	Truck
Estimation Resutls			
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 (Kilometers/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. A dependent variable is transportation time.

B2.2. Specifying Transport Cost Function

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

- A representative firm in machineries industry will make a choice between truck and air transport and choose the mode with the higher probability in (B.5).
- A representative firm in the other industries will make a choice between truck and sea transport and choose the mode with the higher probability in (B.5).

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

$$C_{ij}^{s,M} = \underbrace{\left[\left(\frac{dist_{ij}}{Speed_M}\right) + \left(1 - Abroad_{ij}\right) \times ttrans_M^{Dom} + Abroad_{ij} \times ttrans_M^{Intl}\right]}_{Total\ Transport\ Time} \times ctime_s$$
$$+ \underbrace{dist_{ij} \times cdist_M}_{Physical\ Transport\ Cost} + \underbrace{\left(1 - Abroad_{ij}\right) \times ctrans_M^{Dom} + Abroad_{ij} \times ctrans_M^{Intl}}_{Physical\ Transshipment\ Cost} \quad , \text{(B.6)}$$

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

The parameters in the transport function are determined as follows. First, by using the parameters obtained from the results of Section B2.1 and borrowing some parameters from the ASEAN Logistics Network Map 2008 by JETRO, we set some of the parameters in the transport function as in Table B6. Notice that our estimates of $Speed_{\mathrm{Air}}$ and $ttrans_{\mathrm{Air}}^{Intl}$ in Table B5 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 ASEAN Logistics Network Map 2008.

Table B6. Parameters from Estimation and ASEAN Logistics Network Map 2008

	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 transshipment costs in the international transport from Bangkok to Hanoi. The parameters $ttrans_M^{Dom}$ and $ctrans_M^{Dom}$ for sea and air include one-time loading at the origin and one-time unloading at the destination.

Second, after substituting those parameters for the equation (B.6) under domestic transportation, $C_{ij}^{s,M}$ becomes a function of $dist_{ij}$ and $ctime_s$. To meet the above-mentioned assumptions on firms' behavior, we add the following conditions:

- 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 $dist_{ij}$, the line drawn by the function in truck intersects with it in air at only one point for the machineries industry and with it in sea, at only one point for the other industries for all non-negative $dist_{ij}$.

Under the probability equivalent (domestic) distances in Table B4, 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 B7. The functions meet the above conditions.

Table B7. 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, substituting again these parameters 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 using the probability equivalent (international) distances in Table B4 again, we can calculate $ctrans_{\mathrm{Air}}^{Intl}$ and $ctrans_{\mathrm{Sea}}^{Intl}$ for each industry. Last, $ctrans_{\mathrm{Sea}}^{Intl}$ is uniquely set as the average among the other industries. These parameter values are reported in Table B8. The functions obtained also fulfill the above conditions.

Table B8. Costs for Transshipment in International Transport ($ctrans_M^{Intl}$): US$

	Truck	Sea	Air
$ctrans_M^{Intl}$	500	504.2	1380.1

Source: Authors' calculation

APPENDIX C: Elasticity of Substitution in Services

This appendix explains how we estimate the elasticity of substitution in the services sector. Our theoretical background lies in Anderson and van Wincoop (2003). Under the usual assumptions (e.g., CES utility function), we derive the following gravity equation for the *goods* sector (equation 9 on page 175):

$$x_{ij} = \frac{y_i y_j}{y^W}\left(\frac{\tau_{ij}}{\Pi_i P_j}\right)^{1-\sigma}, \tag{C.1}$$

where

$$\Pi_i \equiv \left(\sum_j \left(\tau_{ij}/P_j\right)^{1-\sigma}\theta_j\right)^{1/(1-\sigma)},\quad P_j \equiv \left(\sum_i \left(\tau_{ij}/\Pi_i\right)^{1-\sigma}\theta_i\right)^{1/(1-\sigma)}, \text{ and } \theta_j \equiv y_j / y^W .$$

The variables x_{ij}, y_i, τ_{ij}, and y^W are the nominal value exports from countries i to j, total income of country i, iceberg trade costs from countries i to j, and world nominal income, respectively. The coefficient σ denotes the elasticity of substitution among varieties. Taking logs in equation (C.1), we obtain:

$$\ln x_{ij} = \ln y^W + \ln y_i + \ln y_j + (1-\sigma)\tau_{ij} + (\sigma-1)\ln\Pi_i + (\sigma-1)\ln P_j . \tag{C.2}$$

We simply apply this gravity formulation in the goods sector into the services sector. Furthermore, due to data limitations, we drop the last two terms, the so-called "multilateral resistance terms," although we really recognize such a treatment is quite serious.

In this paper, we specify the trade cost function as:

$$\tau_{ij} = \left(1 + tax_j\right)\cdot Dist_{ij}^{\alpha_1}\cdot e^{\alpha_2 RTA_{ij}} e^{\alpha_3 Continent_{ij}} e^{\alpha_4 Language_{ij}} e^{\alpha_5 Colony_{ij}} . \tag{C.3}$$

The variable *dist* is geographical distance between trading partners. The variable *RTA* is a binary variable taking unity if trading partners conclude regional trade agreements (RTAs) and zero otherwise. The variable *tax* is the corporate tax rate (100:*tax*%). The variable *language* is a linguistic dummy variable that takes one if the same language is spoken by at least 9% of the population in both countries. The variable *colony* is a binary variable that takes one if an importer (an exporter) was ever a colonizer of an exporter (importer) and zero otherwise. Introducing this trade cost function into equation (C.2) and taking logs, we obtain:

$$\begin{aligned} \ln x_{ij} &= \ln y^{W} + \ln y_{i} + \ln y_{j} + (1-\sigma)\ln(1+tax_{j}) \\ &\quad + (1-\sigma)\alpha_{1}\ln Dist_{ij} + (1-\sigma)\alpha_{2}RTA_{ij} + (1-\sigma)\alpha_{3}Continent_{ij} \end{aligned}.$$

Thus, the coefficient for tax variable gives us direct information on the elasticity of substitution.

Our data set is an unbalanced panel between 2000 and 2005. Data on international trade values in services have been obtained from "Organisation for Economic Co-operation and Development (OECD) Statistics on International Trade in Services." We restrict the sample sector only to other services: communications services; construction services; insurance services; financial services; computer and information services; royalties and license fees; other business services; and personal, cultural, and recreational services. An RTA dummy is constructed using the lists of RTAs provided on the website of the World Trade Organization (WTO). The source of geographical distance and other dummy variables is the website of Centre d'Etudes Prospectives et d'Informations Internationales (CEPII).

Our estimation of gravity provides us an elasticity of “2.93893.” There are two noteworthy points. The first one is a shortcoming due to the use of services trade data. The services trade statistics in the OECD database are the balance-of-payments basis, which primarily covers modes 1 and 2. This implies that our estimate is based on a quite-limited part of services. Second, in the OECD database, trade data between non-OECD countries are not available. Thus, it does not include almost all trade among our GSM sample countries. In other words, our estimation is valid only when we assume that the elasticity of substitution in services is almost same between developed countries (OECD countries) and developing countries (GSM countries).

Appendix D: Data Description

Bangladesh:

The data are based on three-sector (primary, manufacturing, and service) GDP data by state from various sources. Then the manufacturing sector was divided into five subsectors using value-added data from the industrial censuses conducted in 2002 and 2003.

Cambodia:

Cambodia's GDP data are available on the national level. The Japan International Cooperation Agency (JICA) estimated provincial income and employed labor in three industries, namely, primary, secondary, and tertiary industries based on Cambodia's socioeconomic survey iCSES03-05j conducted between 2003 and 2005. Provincial gross value added by industries was calculated by applying the ratio of income to national GDP. Nationwide M1 to M5 was calculated based on annual statistics published by the appropriate authority and used as a coefficient to divide provincial GDP of secondary industries into five sectors.

China, Hong Kong, and Macau:

For China, the shares of the number of employees in each industry at the provincial level were used to divide provincial GDP, and then the derived values were considered as industrial GDP at the provincial level. Data on the GDP of the subdivisions of provinces were collected from the 2004 provincial statistical yearbook. Employment data were collected from the 2004 provincial economic census yearbook.

Data on Hong Kong's GDP and employment were obtained from the 2003 annual survey of industrial production and the 2003 social and economic trends in Hong Kong. Data used for the simulation were derived using the same procedure done for the China data.

The 2005 statistics yearbook was used to obtain relevant data for Macau. Note, however, that only employment data in the textile industries were available. The data used for simulations were derived in the same way as the China data.

India:

Population data were derived from the website http://www.censusindia.gov.in/. Three-sector (primary, manufacturing, and service) GDP data were obtained from the statistics office of each state. Manufacturing GDP in five sectors was compiled from the value added by industry in the Indian annual survey of industry (ASI). District-level GDP was not available for some states, and uniform GDP per capita was used for districts in the same state.

Lao PDR:

Provincial-level industrial statistics for Laos were obtained from several sources. Population and value-added figures for each province were based on mostly unpublished annual provincial reports on the implementation of the socioeconomic plan.

These provincial value added are divided among three industries, namely, agriculture, industry, and service, in source. The value added for industry of each province was then used to create the value added for five sectors by splitting them according to the provincial share of labor in M1 to M5. The labor share in M1 to M5 for each province was calculated from the nationwide business establishment survey in 2005.

Malaysia:

Malaysia's data are based on three-sector (primary, manufacturing, and service) GDP data by state culled from various sources. The manufacturing sector is divided into five subsectors using value-added data from the establishment survey provided by the Department of Statistics.

Myanmar:

Data consisted of national-level, three-sector GDP data and income per capita by state based on the Report of 1997: Household Income and Expenditure Survey, published by the Central Statistical Organization. The manufacturing sector was divided into five subsectors using data from Table 6.11 in Myat Thein's (2004) Economic Development of Myanmar.

Singapore:

We used sectoral GDP data from the economic survey of Singapore. The transport sector was divided into automotive and others using the data provided by Singstat.

Thailand:

The data for Thailand were produced in the same way as the data for China. The data were collected from the manufacturing industrial survey for Bangkok and the statistical report of Changwat. Data from the following provinces were also obtained: Chonburi (1999); Ayutthaya, Chaiyaphum, Chanthaburi, Chiangrai, Chumphon, Krabi, Lopburi, Mae Hong Son, Mukudahan, Nan, Songkhla, Yala, and Yasothon (2000); Nakhon Panom (2002); Nakhon Ratchasima (2005); other provinces (2001). Some provincial data did not separate automotive industries from transport equipment, but the data on transport equipment were used for automobiles. A small number of establishments in specific industries might be included in the group "others."

Vietnam:

This is based on three-sector (primary, manufacturing, and service) GDP data by state from various sources. The manufacturing sector was divided into five subsectors using value-added data from an establishment survey.

Appendix E: Results of Additional Simulations

E1. The "Missing Link" in EWEC

Scenario

In this scenario, the baseline is changed. The baseline is the state that EWEC has already developed, except for the "missing link" between Mawlamyin-Myawadi routes in Myanmar. The other part of EWEC is "upgraded," meaning cars can run on it at 60 km/h. In addition, border costs (time and money) are already reduced to two hours and one-fifth of the original baseline scenario.

Compared with this new baseline, the development of the "missing link" scenario is as follows:

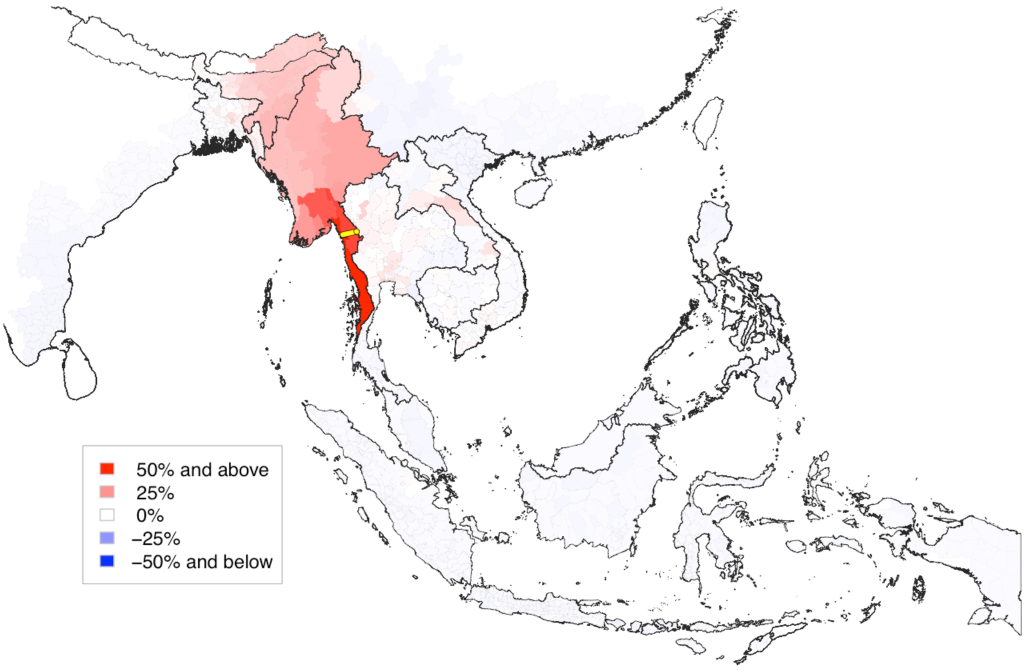
- The route between Mawlamyin-Myawadi is constructed and cars can run on it at 60 km/h.
- At the border between Myawadi-Moe Sot, the time and money costs of custom clearance are reduced to be on par with the new baseline scenario.

Economic Effects

The economic effects of the development of the "missing link" in EWEC are depicted in Figure E1. The figure shows that strong economic effects are observed in Tanintharyi division and in Mon state of Myanmar. Other parts of Myanmar and eastern India also benefit from the development of the "missing link."

Figure E1: Gains in Regional GDP: Development of the "Missing Link" in EWEC

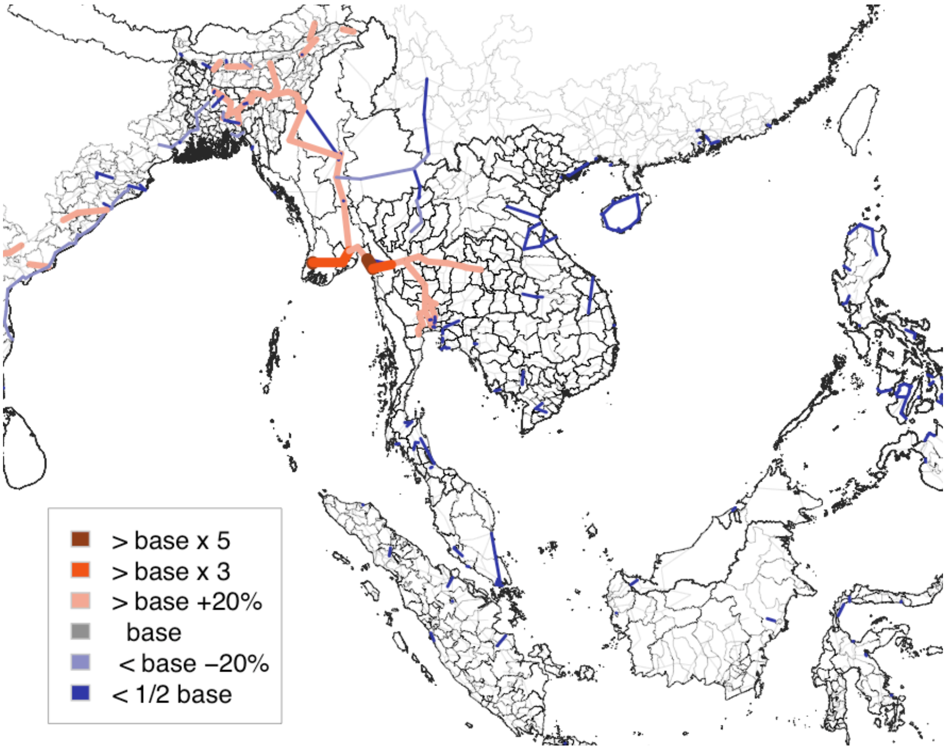
(10 years cumulative)



Traffic Volume

Figure E2 shows the changes in traffic volume as a result of the development of the "missing link" in EWEC. In addition to the newly constructed "missing link" and the routes along EWEC, the routes to Bangkok, Mandalay, and Port Bassein have shown increased traffic. On the other hand, the routes from Mandalay to Yunnan Province of China and to India have decreased traffic.

Figure E2: Changes in Traffic Volume Caused by the Development of the "Missing Link" in EWEC (10 years after)



Tables E1 and E2 show the sea and air routes affected by the development of the "missing link" in EWEC. Table E1 shows that the traffic between Port Madras and Port Bassein has significantly increased, while the route of Port Madras-Port Laem Chabang has fallen into disuse. This is understood to mean that the latter sea route has substituted for the former sea route and the land routes through EWEC from Port Bassein.

Table E1: Sea Routes Most Affected by the Development of the "Missing Link" in EWEC (10 years after)

Sea Route			Traffic Change
Port Madras	-	Port Bassein	9.08
Port Manila	-	Port Laem Chabang	1.19
Port Jakarta	-	Port Laem Chabang	1.10
Port Laem Chabang	-	Port Singapore	1.10
Port Laem Chabang	-	Port Kuching	1.09
Port Saigon	-	Port Madras	0.83
Port Jakarta	-	Port Madras	0.81
Port Kelang	-	Port Madras	0.61
Port Chittagong	-	Port Singapore	0.23
Port Madras	-	Port Laem Chabang	0.00

Table E2 shows that the traffic between Yangon International Airport and other parts of Southeast Asia have decreased. This seems to be substituted for by the land routes going through EWEC. On the other hand, the air route between Yangon and Kolkata has increased traffic.

Table E2: Air Routes Most Affected by the Development of the "Missing Link" in EWEC (10 years after)

Air Routes			Traffic Change
Yangon Intl	-	Netaji Subhash Chandra Bose Intl	1.10
Suvarnabhumi Intl	-	Soekarno Hatta Intl	1.03
Suvarnabhumi Intl	-	Hong Kong Intl	1.01
Suvarnabhumi Intl	-	Macau Intl	1.01
Suvarnabhumi Intl	-	Changi Intl	1.01
Noibai Intl	-	Suvarnabhumi Intl	0.74
Changi Intl	-	Yangon Intl	0.72
Yangon Intl	-	Wujiaba	0.58
Suvarnabhumi Intl	-	Yangon Intl	0.00
Chiang Mai Intl	-	Yangon Intl	0.00

Figures E3 and E4 graphically show the sea and air routes affected by the development of the "missing link" in EWEC.

Figure E3: Sea Routes Most Affected by the Development of the "Missing Link" in EWEC (10 years after)

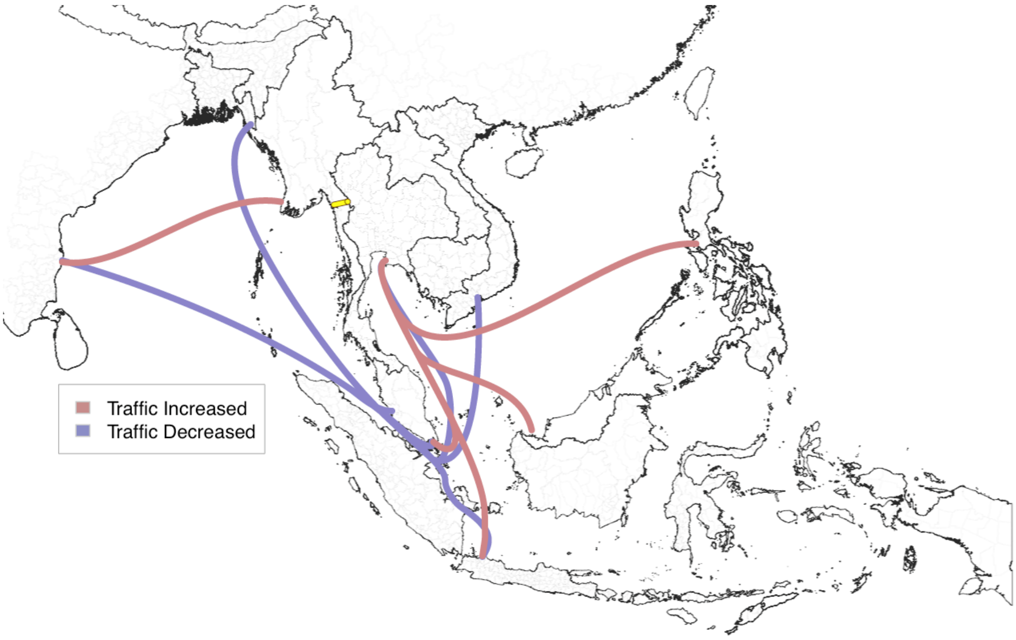
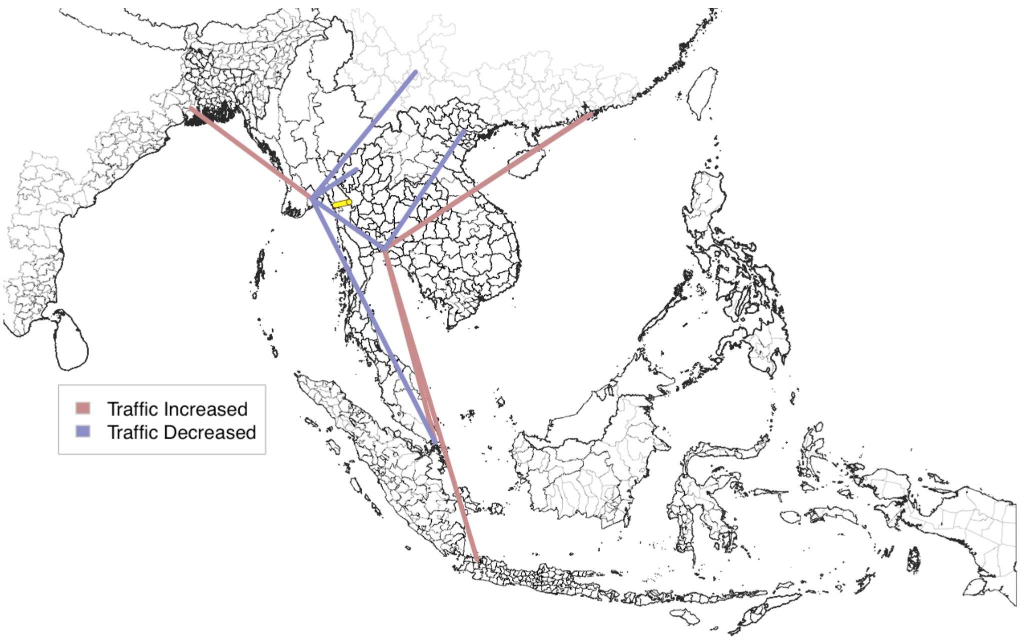


Figure E4: Air Routes Most Affected by the Development of the "Missing Link" in EWEC (10 years after)



E2. Indonesia-Malaysia-Thailand Growth Triangle (IMT-GT)

Scenario (Highway between Bandar Ache and Jakarta, and ro-ro vessels between Penang-Medan and Dumai-Malacca)

In this scenario, one highway and two sea routes are developed. The highway, on which vehicles can run at 60 km/h, starts at Bandar Ache and goes through the eastern part of Sumatra Island and ends at Jakarta. At the Sunda Strait, Bakaheuni and Merak are assumed to be connected by a bridge. Two sea routes, Port Belawan-Port Penang and Port Dumai-Port Malacca, are connected at the speed of 14.7 km/h, on par with the other internationally important routes, and the time cost is reduced to two hours, and money costs are reduced to one-fifth of the baseline scenario.

Economic Effects

The economic effect of the IMT-GT is depicted in Figures E5. In the scenario, Sumatra Island benefits well and other part of the continental regions also benefit, while a few other regions in Kalimantan Island seem to suffer a slight dip in their GDP.

Figure E5: Gains in Regional GDP: IMT-GT (10 years cumulative)

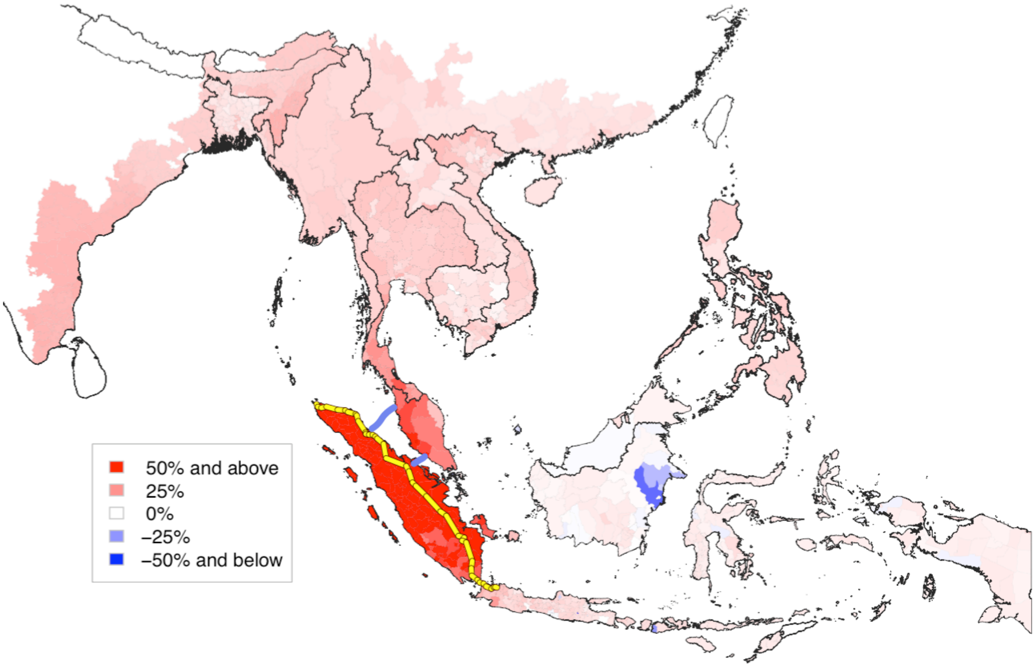
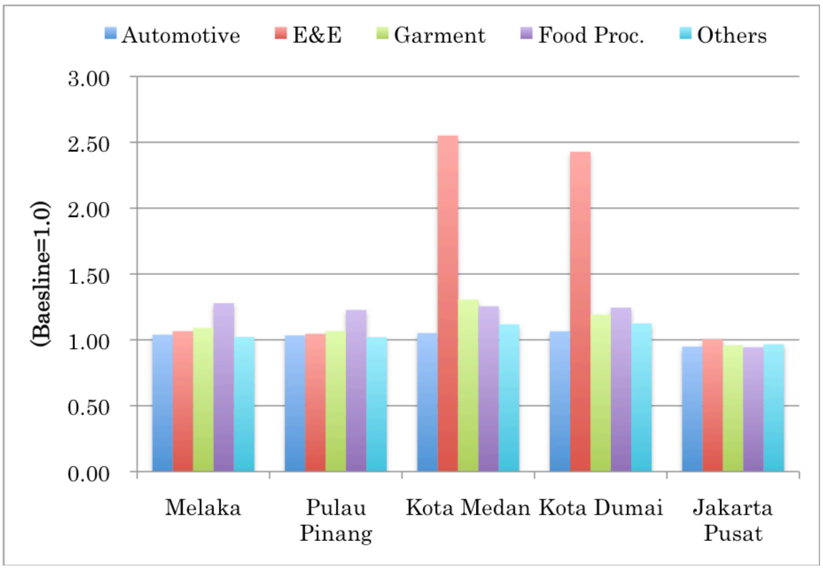


Figure E6 deconstructs the economic effects by industry for five cities near IMT-GT. The economic effects on the E&E industry in Medan and Dumai are outstanding while Melaka and Penang benefit moderately in the food processing industry. On the other hand and surprisingly, Jakarta receives virtually no economic benefits.

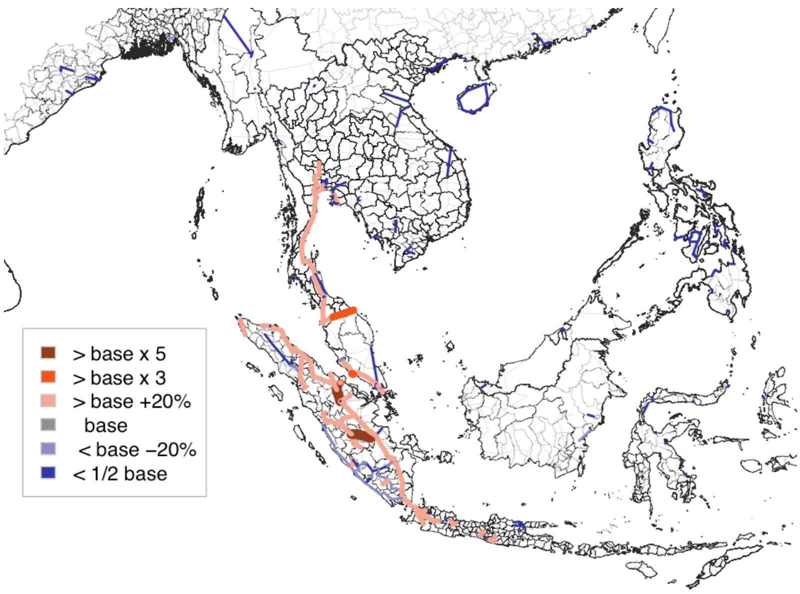
Figure E6 :Ecomic Effects of IMT-GT by Industry (10 years after)



Traffic Volume

Figure E7 shows the changes in the land traffic volume by IMT-GT. It is understood that the traffic volume along the highway though Sumatra Island has increased along with the traffic though the western end of Java Island and from Bangkok area to Malay Peninsula. On the other hand, the alternative route of Sumatra Island has lost its traffic.

Figure E7 : Changes in Traffic Volume by IMT-GT (10 years after)



The development of IMT-GT affects sea and air traffic significantly. Table E3 shows the sea routes most affected by IMT-GT. The sea routes connecting Sumatra and other parts of Indonesia gain traffic. The four international routes between Singapore/Kelang of Malaysia and Indonesia fall into disuse. These routes seem to be substituted for by the sea routes between Penang-Medan and Dumai-Malacca.

Table E3: Sea Routes Most Affected by IMT-GT (10 years after)

Sea Route			Traffic Change
Toboali	-	Tanjung Pandan	8.70
Muntok	-	Port Palembang	2.30
Port Dumai	-	Tanjung Balai Karimun	2.17
Bakaheuni	-	Merak	1.39
Port Kelang	-	Port Madras	1.36
Port Ambon	-	Port Singapore	0.44
Port Singapore	-	Port Palembang	0.00
Port Dumai	-	Port Singapore	0.00
Port Kelang	-	Port Jakarta	0.00
Port Kelang	-	Port Belawan	0.00

Tables E4 shows the air routes most affected by IMT-GT. Most of the air routes that gain traffic significantly involve Kuala Lumpur International Airport. On the other hand, the nearby airports of Thailand, Indonesia, Malaysia, and Singapore seem to lose traffic. While IMT-GT in this simulation does not involve airlines, it shows a significant effect on the traffic of existing air routes.

Table E4: Air Routes Most Affected by IMT-GT (10 years after)

Air Routes			Traffic Change
Phuket Intl	-	Kuala Lumpur Intl	8.08
Kuala Lumpur Intl	-	Wujiaba	2.34
Noibai Intl	-	Kuala Lumpur Intl	2.20
Tansonnhat Intl	-	Kuala Lumpur Intl	2.00
Kuala Lumpur Intl	-	Phnom Penh Intl	1.79
Tansonnhat Intl	-	Changi Intl	0.71
Changi Intl	-	Soekarno Hatta Intl	0.69
Kuala Lumpur Intl	-	Kota Kinabalu Intl	0.57
Kuala Lumpur Intl	-	Bali Ngurah Rai	0.00
Kuala Lumpur Intl	-	Soekarno Hatta Intl	0.00

Figures E8 and E9 graphically depict the air/sea routes affected by IMT-GT. Figure E8 shows that the trans-Sumatra highway and the Medan-Penang and Dumai-Malacca sea routes substitute for the competing sea routes. Figure E9 shows, somewhat surprisingly, that the utilization of Kuala Lumpur International Airport increases in the IMT-GT.

Figure E8: Sea Routes Most Affected by IMT-GT (10 years after)

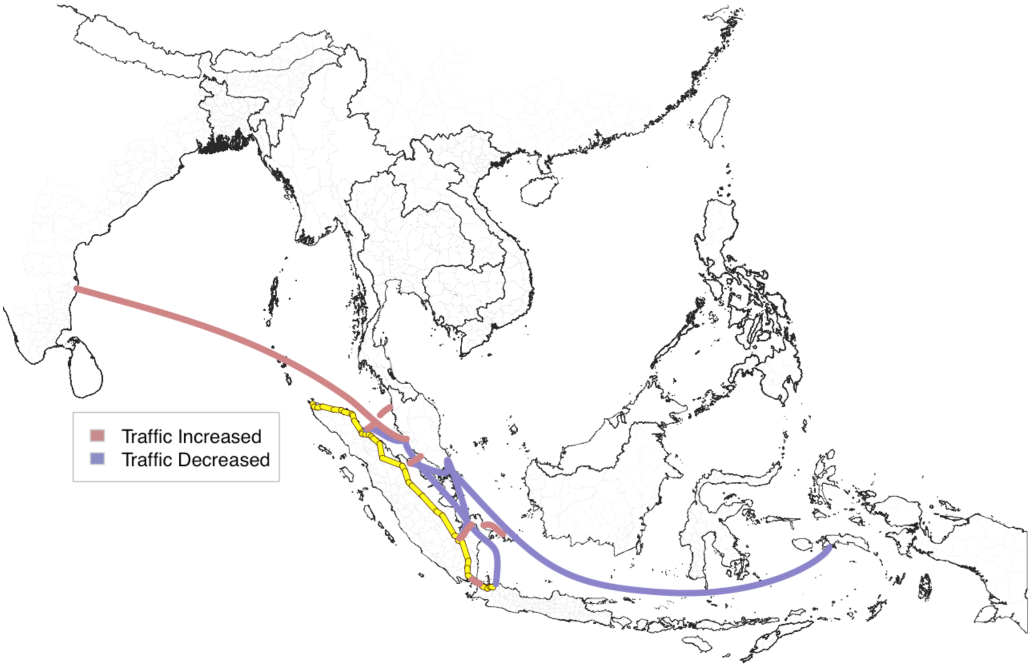
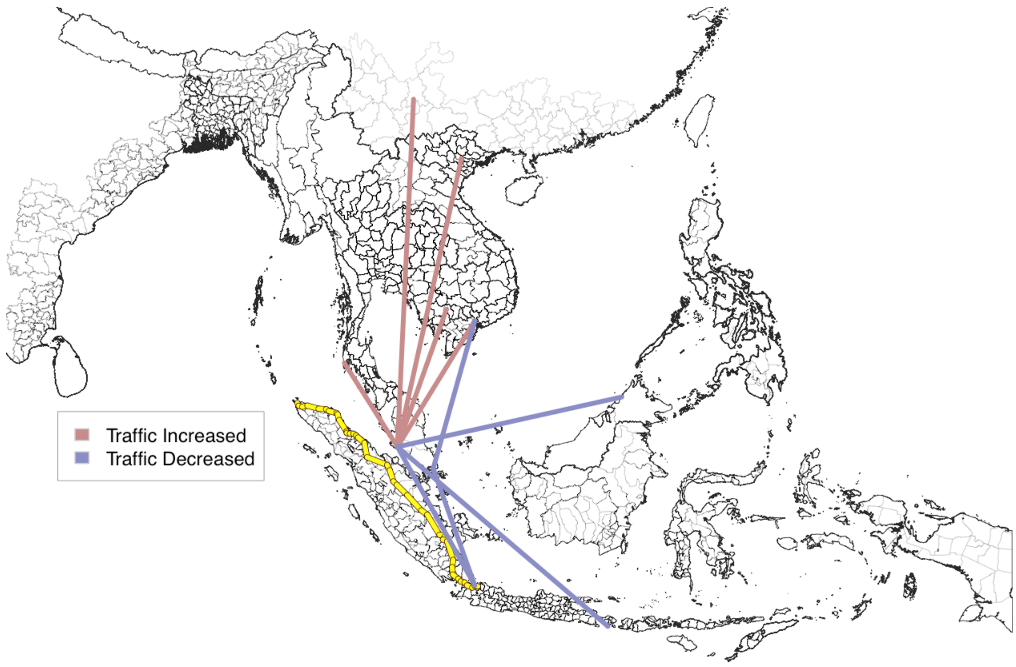


Figure E9: Air Routes Most Affected by IMT-GT (10 years after)



E3. ASEAN Highways

We checked the effects of the development of ASEAN Highway Networks from No.1 to No.16 (Table E5).

Table E5: ASEAN Highway Networks

No.	Origin - Destination	Criteria
1	Tamu (Myanmar / India Border) - Mandalay - Payagyl (Including Payagyl - Yangon) - Myawadi / Mae Sot (Myanmar / Thailand Border) - Tak - Bangkok - Aranyaprahet / Pol Pet (Thailand / Cambodia Border) - Sisophon - Phnom Penh - Bavet / Moc bal (Cambodia / Vietnam Border) - Ho Chi Minh City (Including Dong Nal - Vung Tau) - Danang - Hanoi - Haiphong	Capital - Capital
2	Muse (Myanmar / China Border) - Thibaw - Mandalay Melktila - Loilem (Including Loilem - Thibaw) - Keng Tung (Including Keng Tung - Monglar) - Thackilelk / Mae Sal (Myanmar / Thailand Border) - Tak - Bangkok - Chumphon Hat Yal - Sadao / Bukit Kayu Hitam (Thailand / Malaysia Border) - Ipoh - Kuala Lumpur - Seremban - Tanj'ung Kupang/ Tuas (Malaysia / Singapore Border 2nd link) (Including Johor Bahru - Malaysia / Singapore Border 1st link) - Singapore (Ferry Service) - Jakarta (Indonesia) - Semarang - Surakarta Surabaya - Denpasar	Capital - Capital
3	Boten (Lao PDR / China Border) - Luang Namtha - Huai Sal / Chiang Khong (Lao PDR / Thailand Border) - Chiang Rai	Linkage to China
4	Natrey (Lao PDR) - Oudomsay - Luang Phrabang - Vientiane - Thanalaeng / Nong Khal (Lao PDRiThalland Border) - Khon Kaen - Saraburl - Bangkok	Capital - Capital
5	Hanoi (Vietnam) - Tay Trang / Deo Tay Chang (Vietnam / Lao PDR Border) - Oudomsay - Pak Beng - Muang Ngeon / Hualkon (Lao PDR / Thailand Border) - Nan - Phitsanulok - Nakhon Sawan	Seaport - Capital
6	Vientiane (Lao PDR) - Savannakhet - Muang KhongNeun Kham (Lao PDR / Cambodia Border) - Streng Treng - Phnom Penh - Sihanoukville Port	Capital - Capital
7	Vinh (Vietnam) - Keo Nua/Nape (Vietnam/Lao PDR Border) - Laksao - Ban Lao - Thakhek / Nakhon Phanom (Lao PDR / Thailand Border) - Udon Thani	Seaport - Major City
7A	Vung Ang Port (Vietnam) - Mu Ghla (Vietnam / Lao PDR Border) - Thakhek	Seaport - Major City
7B	Quang Ngal Port - Kontum - Ban Het (Vietnam / Lao PDR Border) -Attapeu - Pakse	Seaport - Major City
7C	Hanoi (Vietnam) - Lao Cal (Vietnam/China Border)	Capital - China
8	Tak (Thailand) - Khon Kaen - Mukdahan / Savannakhet (Thailand / Lao PDR Border) - Lao Bao (Lao PDR / Vietnam Border) - Dong Ha	Major City - Seaport
9	Savannakhet / Mukdahan (Lao PDR / Thailand Border) - Yasothon - Burlram - Sakaeo - Phanom Sarakham - Sattahip	Seaport - seaport
9A	Phnom Sarakham - Kabinburl - Pakthongchal - Nakhon Ratchasima	Seaport - Lao PDR
10	Thaton (Myanmar)-Mawlamylne - Tavoy - Mugul - Lenya - Kawthong (including Lenya-Khlong Loy (Myanmar/Thalland Border) - Bang Saphan)	Country's back bone-port
11	Tavoy (Myanmar) - Sinptyutang/Bong Ti (Myanmar/Thailand Border) - Kanchanaburl - Bangkok - Laem Chabung - Maptaput - Hat Lek/Koh Kong (Thailand/ Cambodia Border) - Sre Ambel - Ho Chi Minh City - Kontum - Danang	Seaport - Seaport

Table E5: ASEAN Highway Networks (contd.)

No.	Origin - Destination	Criteria
12	Hat Yai (Thailand) - Pattani - Narathlwat - Sungal Kolok / Rantau (Thailand/Malaysia Border) - Kota Bharu - Kuala Terengganu - Kuantan - Mersing - Johore Bahru (Malaysia/Singapore Border) - Singapore	International linkages Major City - Major City
13	Kota Bharu (Malaysia) - Sungal Patani (Malaysia)	Country's back bone-port
13A	Port Klang (Malaysia) - Kuala Lumpur - Kuantan (Malaysia)	Seaport - Seaport
13B	Kuantan (Malaysia) - Segamat - Yong Peng (Malaysia)	Major City - Major City
13C	Kuching (Malaysia, Sarawak) - Serian - Bintulu - Miri - Sg. Tujoh (Malaysia/Brunei Darussalam Check Point) - Brunei Darussalam - Kuala Lurah (Brunei Darussalam/Malaysla Check Point) - Limbang / Puni (Malaysia / Brunei Darussalam Check Point) - Brunei - Labu (Brunei / Malaysia Check Point) - Lawas - Sindumin - Kota Kinabalu - Sandakan - Lahad Datu - Tawau - Serudong/Nunukan (Malaysia, Sabah / Indonesia Border) - Samarinda - Banj'armasin - Palangka Raya - Pontianak - Entikong/Tebedu (Indonesia/Malaysia,Sarawak Border) - Serian	Major City - Capital City in Pan Borneo Island
14	Banda Aceh (Indonesia) - Medan - Dumal - Palembang - Bakahuni	Country's back bone-port
15	Tebingtinggi (Indonesia) - Padang - Bakahuni - (Ferry Service) - Merak - Jakarta - Bandung - Jogyakarta - Surakarta (Indonesia)	Major Cities - Major Cities
16	Laoag City (Philippines) - Manila - Matnog - (Ferry Service) - San Isidro - Taeloban City - Liloan - (Ferry Service) - Lipata - Surigao City - Davao City - General Santos City - Zamboanga City (Philippines)	Country's back bone-port

Source: ASEAN official website (http://www.aseansec.org/ahnp_a.htm)

The development is the combination of the construction and upgrading of the infrastructure, customs facilitation along the corridor, and the establishment of a new sea routes. Specifically, the overhead time consumed at the border is reduced to two hours. In addition to that, the money costs going though these borders are reduced to one-fifth of the baseline scenario. The “upgrading” of land routes means cars can run on it at 60 km/h, and speed going through the sea routes increases to become twice as fast than the baseline scenario. The economic effects and the changes in traffic volume as a result of the development of Each ASEAN highway are depicted in Figures E10 to E55.

Figure E10: Gains in Regional GDP: ASEAN Highway No. 1 (10 years after)

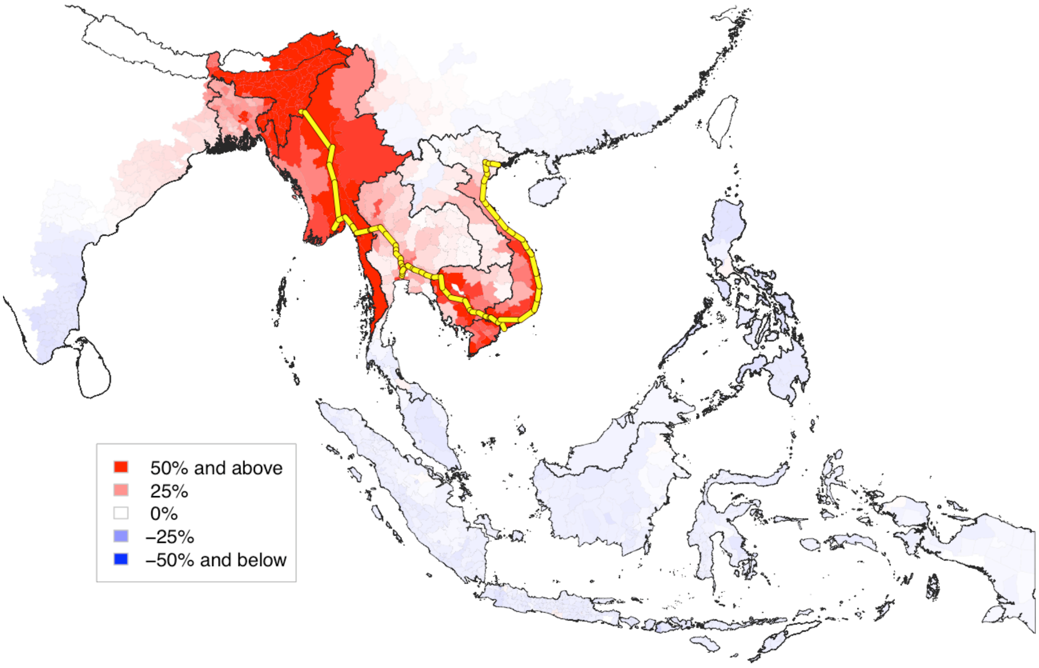


Figure E11: Changes in Traffic Volume by ASEAN Highway No.1 (10 years after)

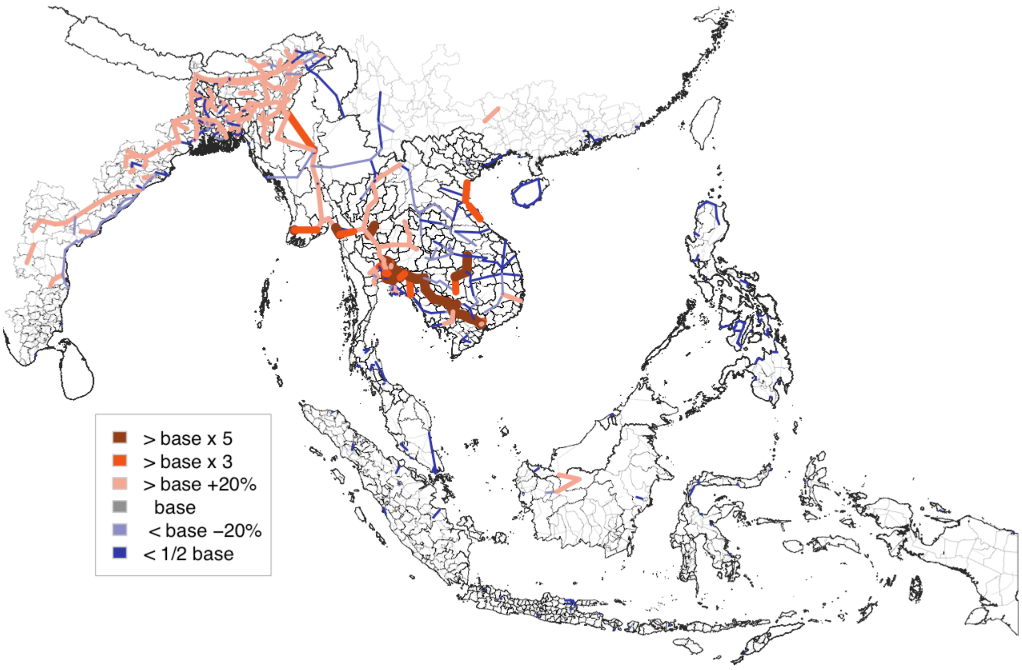


Figure E12: Gains in Regional GDP: ASEAN Highway No. 2 (10 years cumulative)

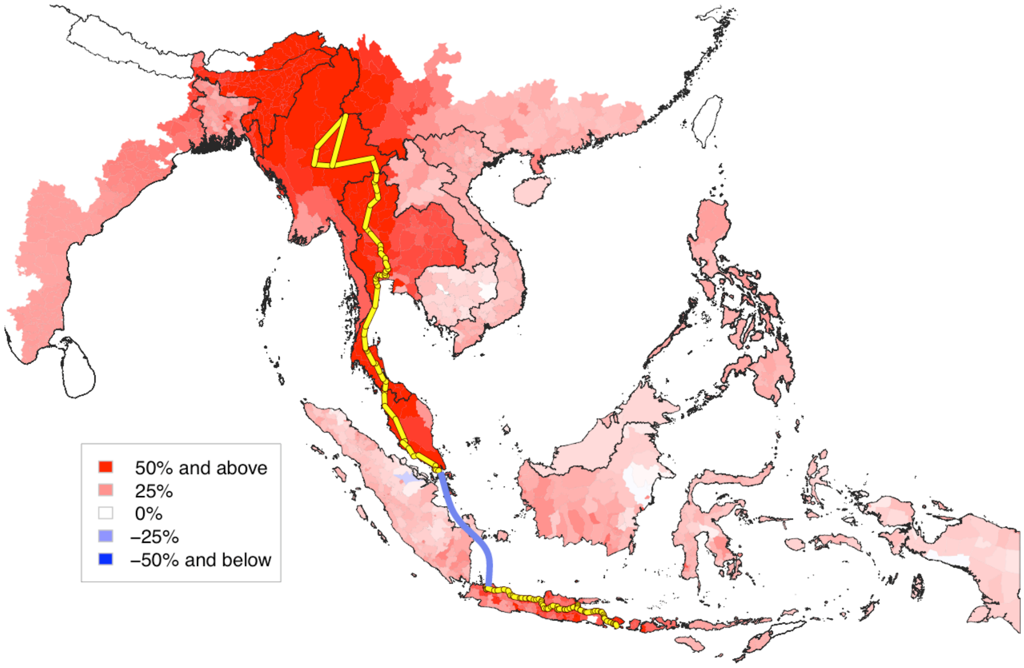


Figure E13: Changes in Traffic Volume by ASEAN Highway No.2 (10 years after)

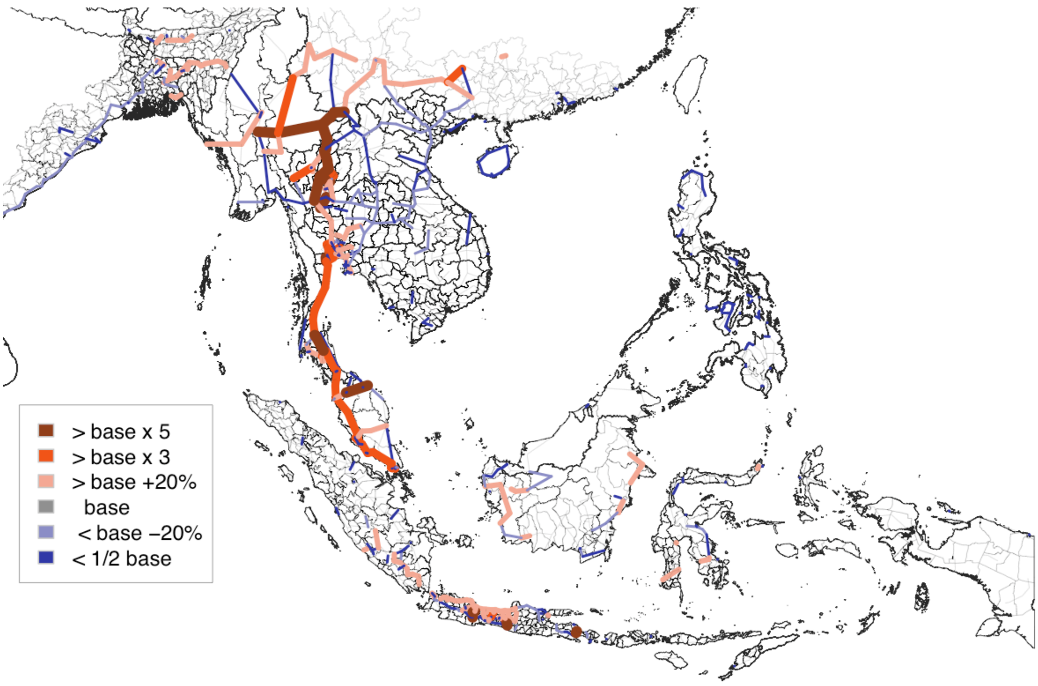


Figure E14: Gains in Regional GDP: ASEAN Highway No. 3 (10 years cumulative)

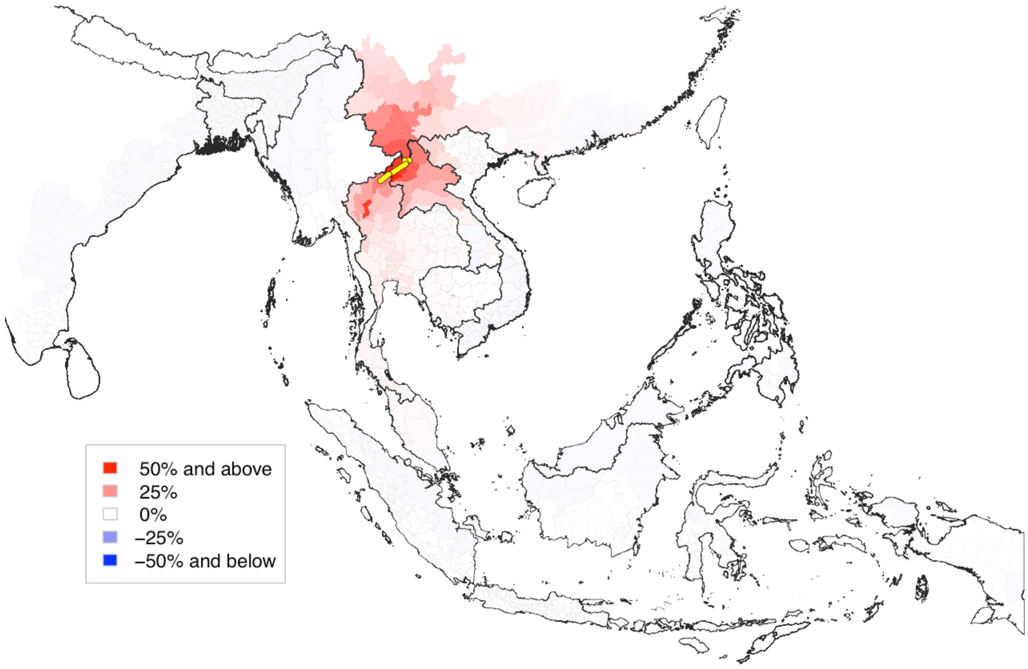


Figure E15: Changes in Traffic Volume by ASEAN Highway No.3 (10 years after)

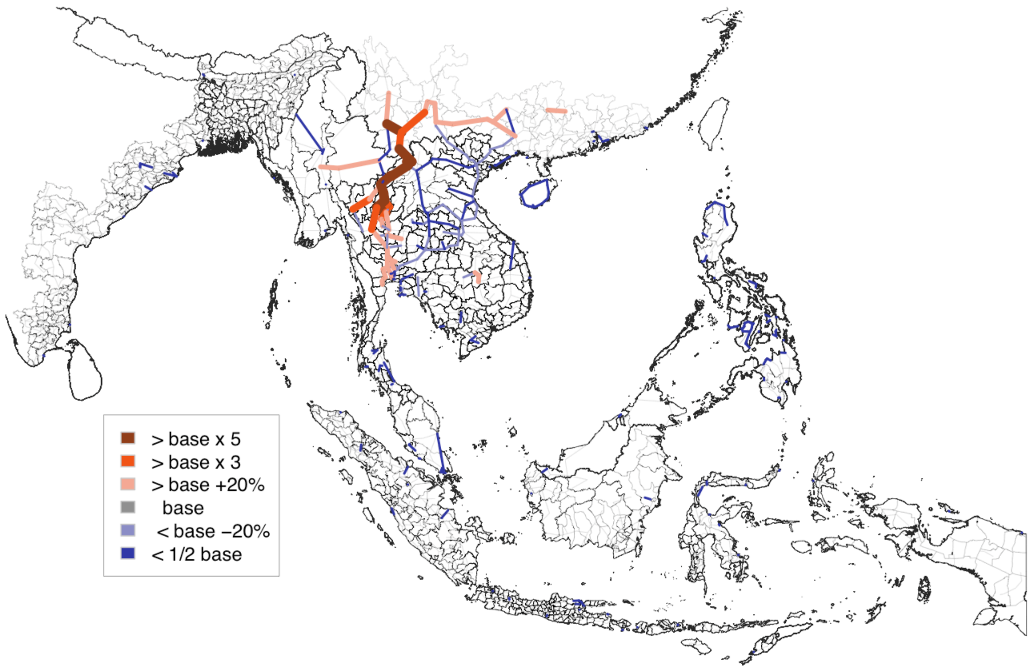


Figure E16: Gains in Regional GDP: ASEAN Highway No. 4 (10 years cumulative)

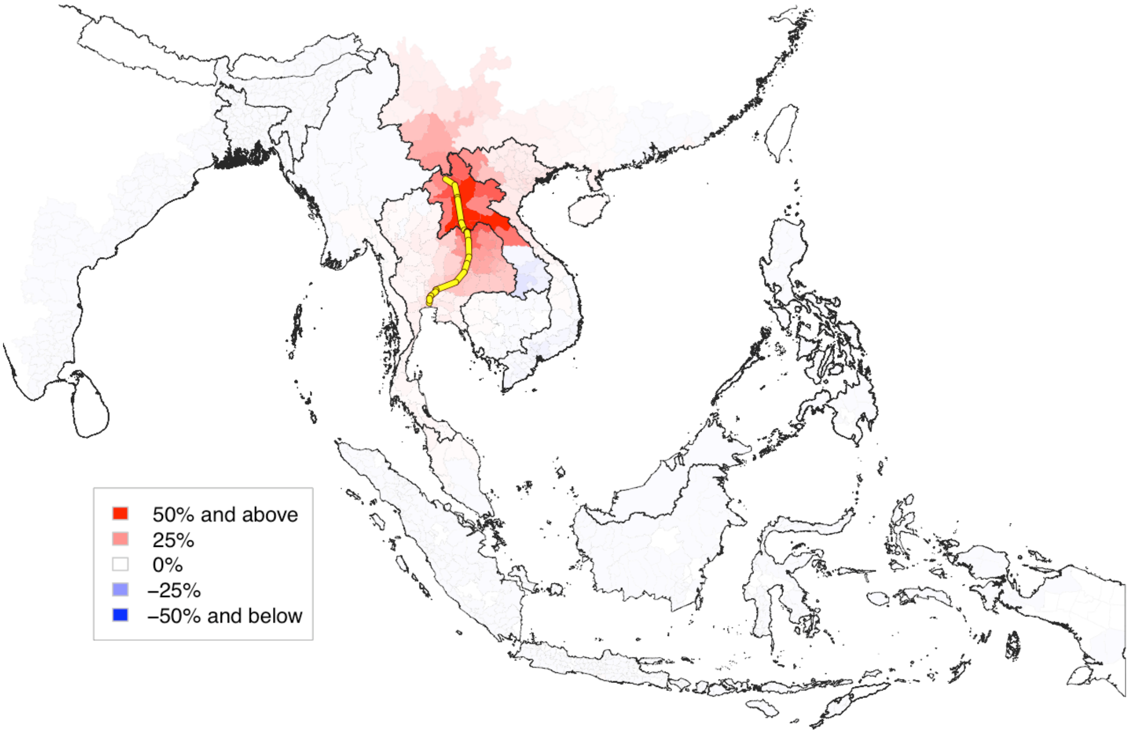


Figure E17: Changes in Traffic Volume by ASEAN Highway No.4 (10 years after)

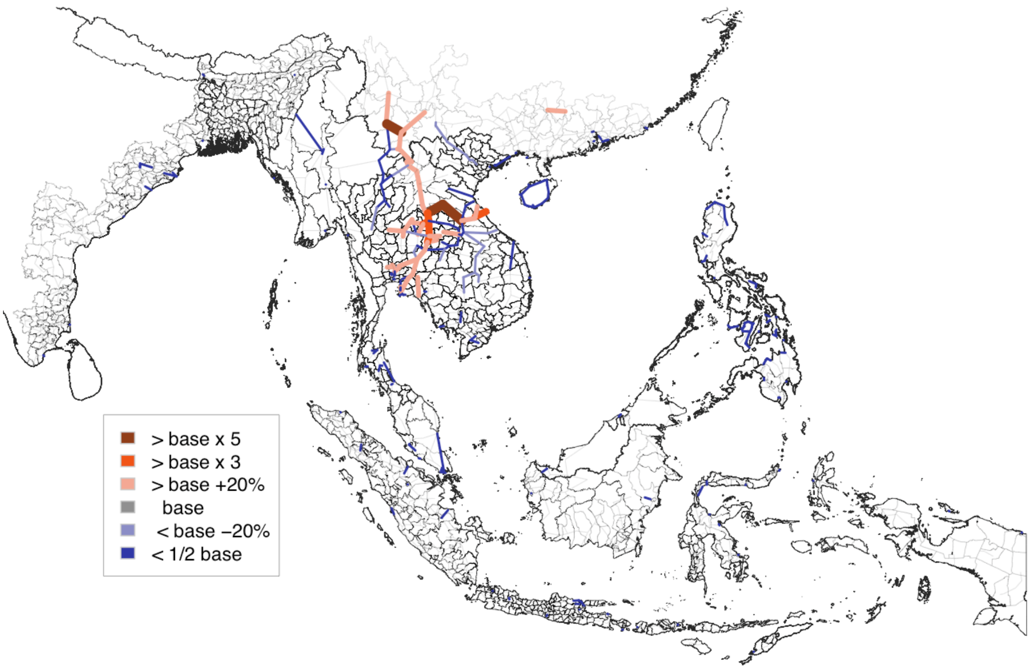


Figure E18: Gains in Regional GDP: ASEAN Highway No. 5 (10 years cumulative)

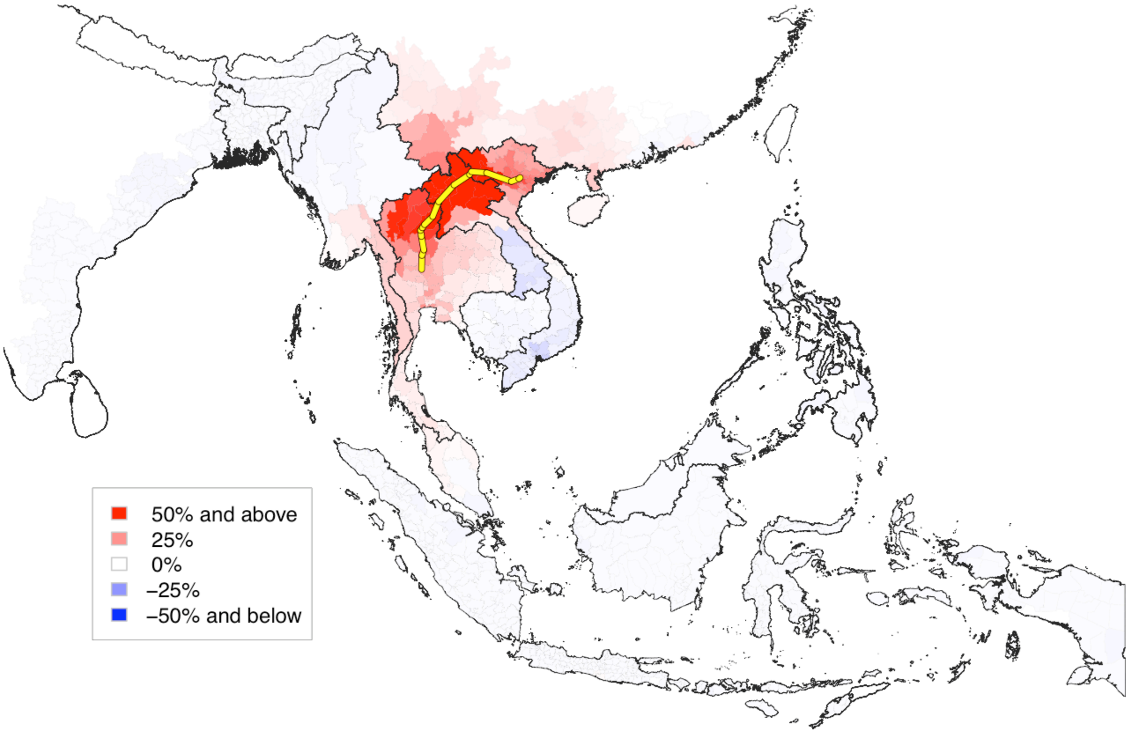


Figure E19: Changes in Traffic Volume by ASEAN Highway No.5 (10 years after)

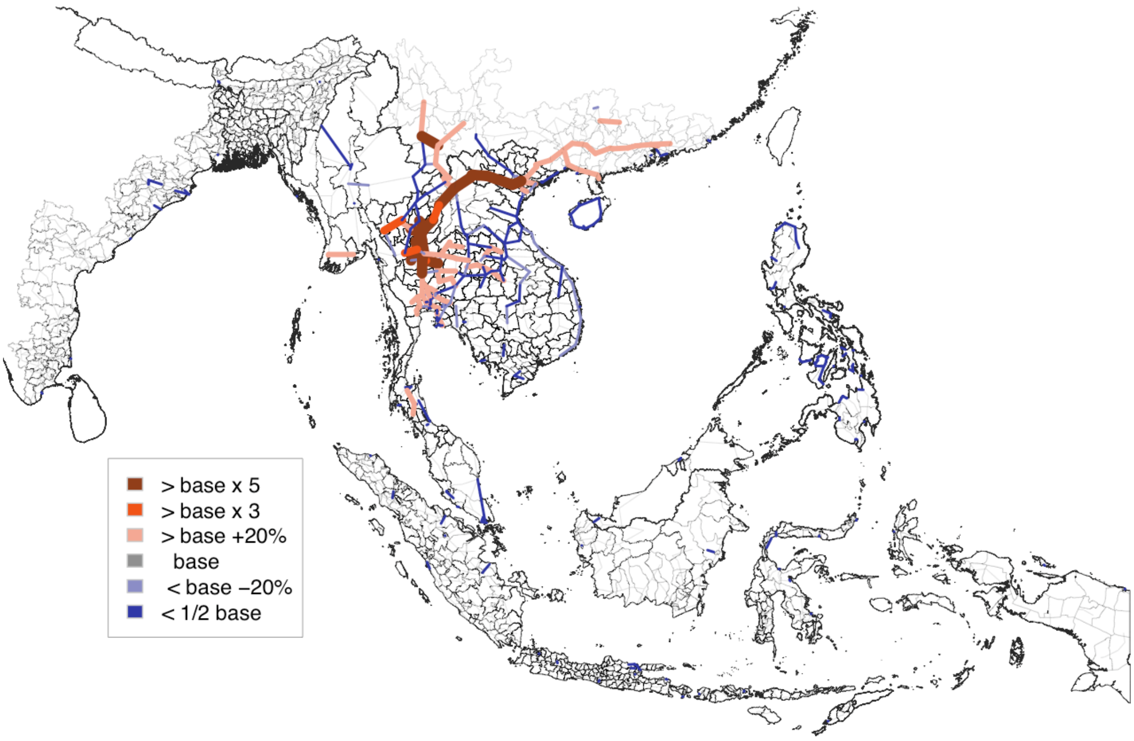


Figure E20: Gains in Regional GDP: ASEAN Highway No. 6 (10 years cumulative)

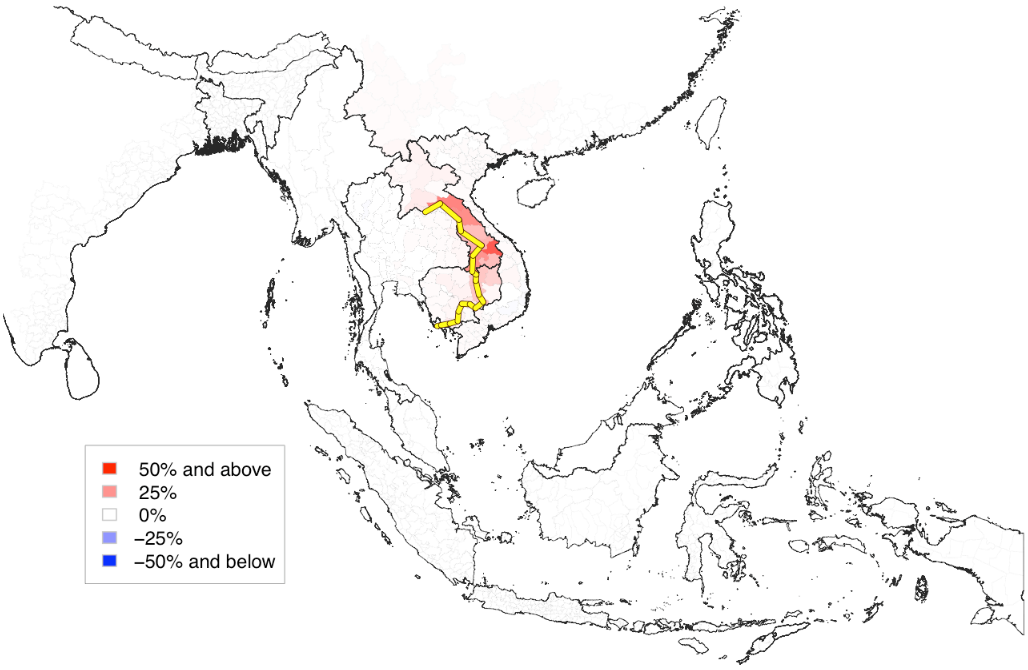


Figure E21: Changes in Traffic Volume by ASEAN Highway No.6 (10 years after)

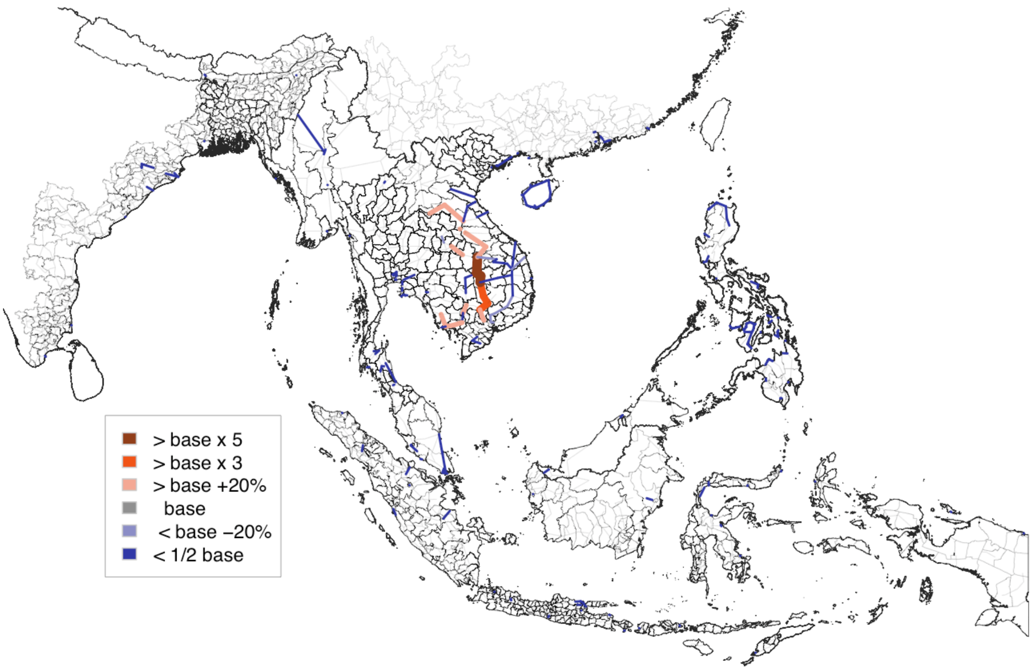


Figure E22: Gains in Regional GDP: ASEAN Highway No. 7 (10 years cumulative)

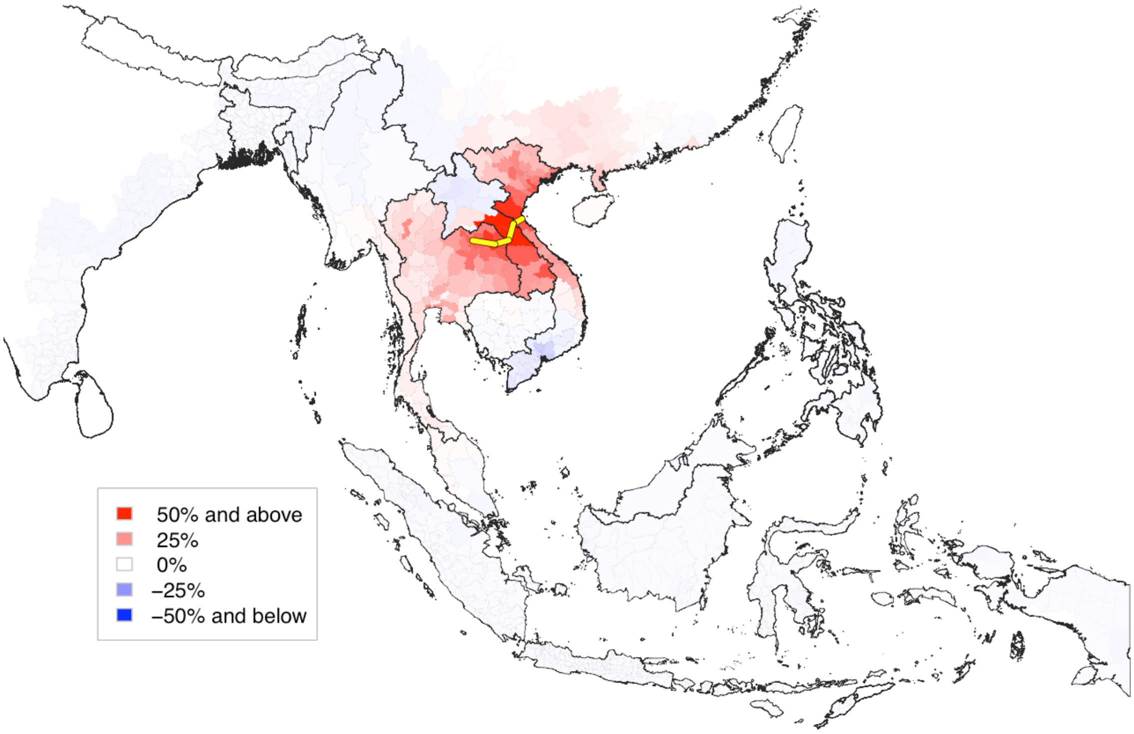


Figure E23: Changes in Traffic Volume by ASEAN Highway No.7 (10 years after)

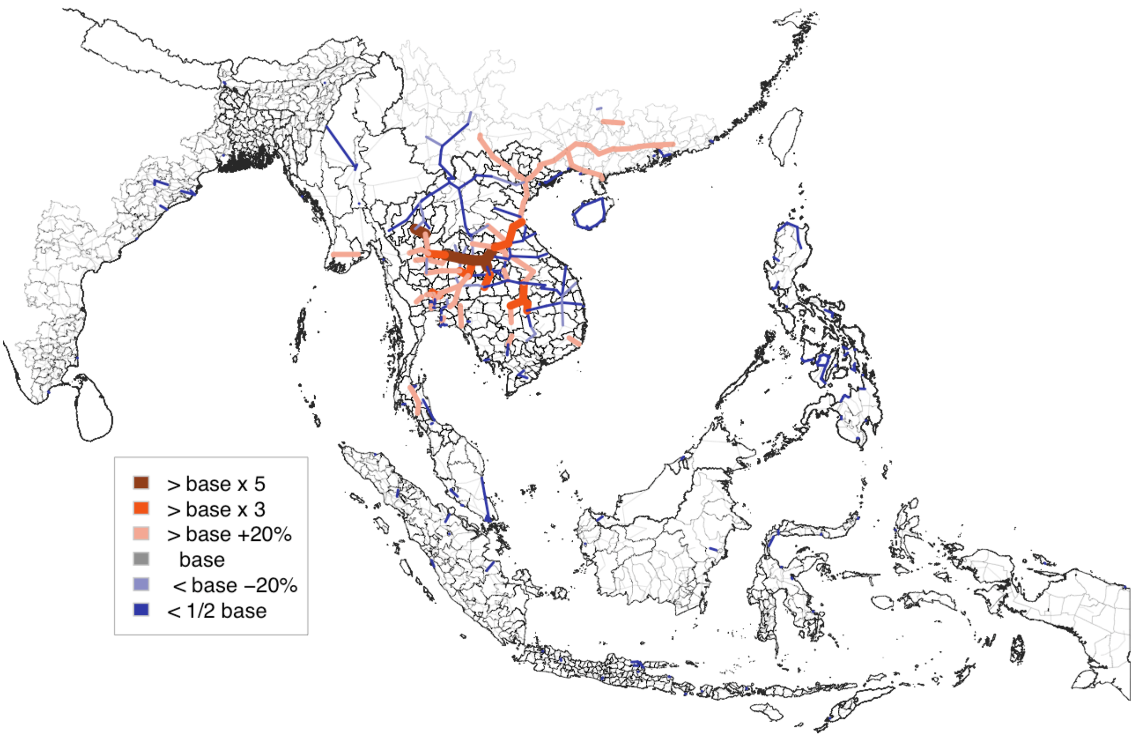


Figure E24: Gains in Regional GDP: ASEAN Highway No. 7A (10 years cumulative)

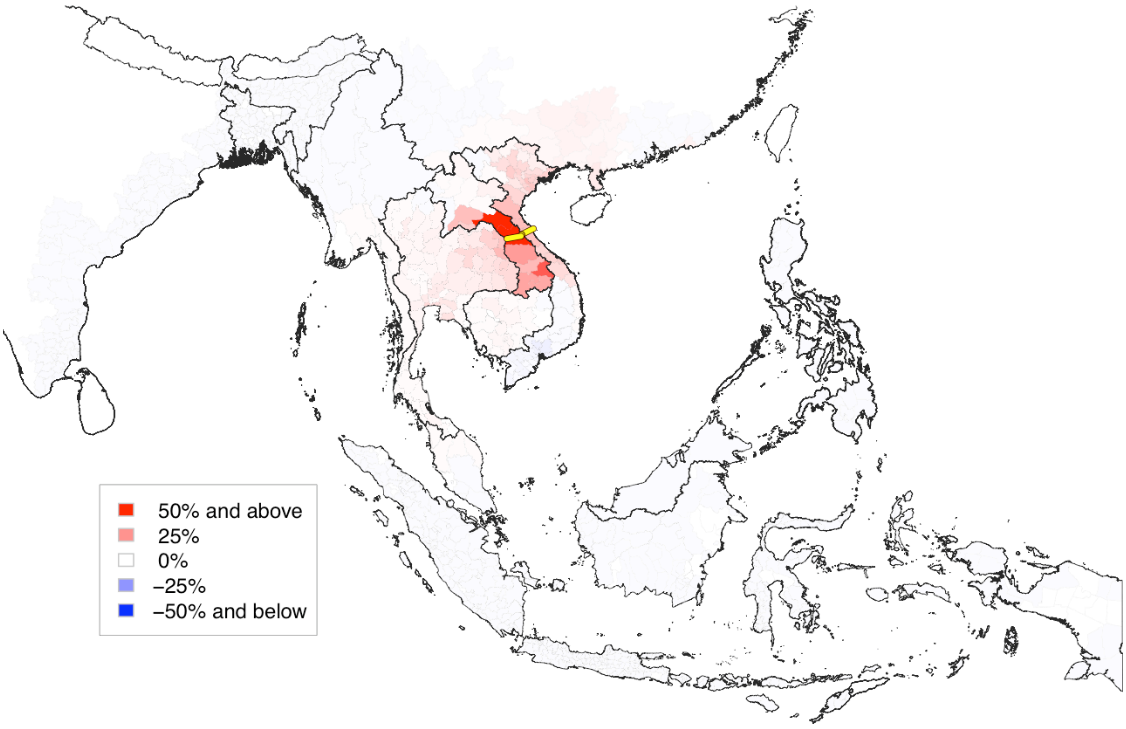


Figure E25: Changes in Traffic Volume by ASEAN Highway No.7A (10 years after)

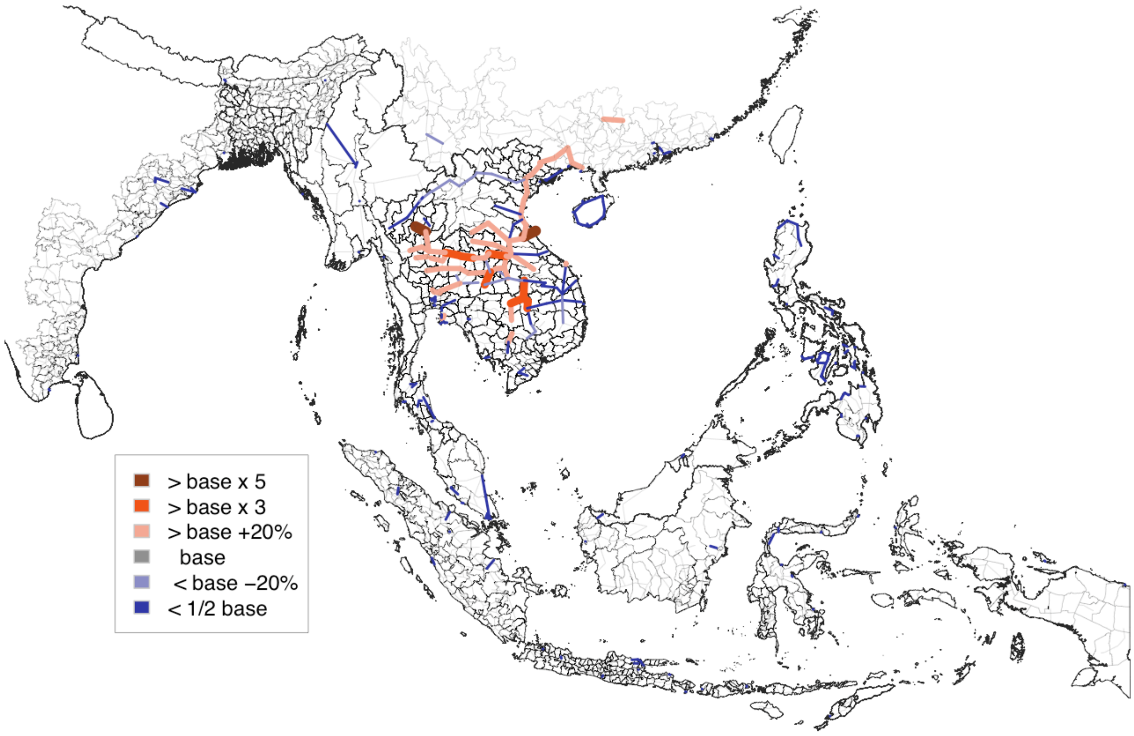


Figure E26: Gains in Regional GDP: ASEAN Highway No.7B (10 years cumulative)

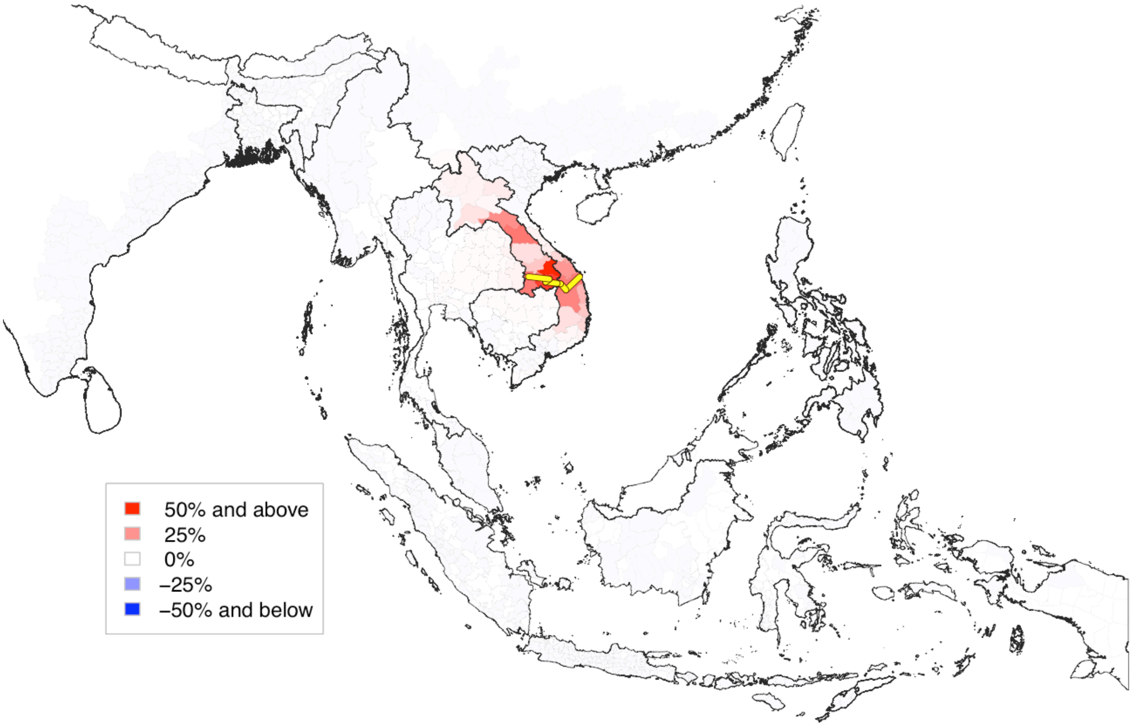


Figure E27: Changes in Traffic Volume by ASEAN Highway No.7B (10 years after)

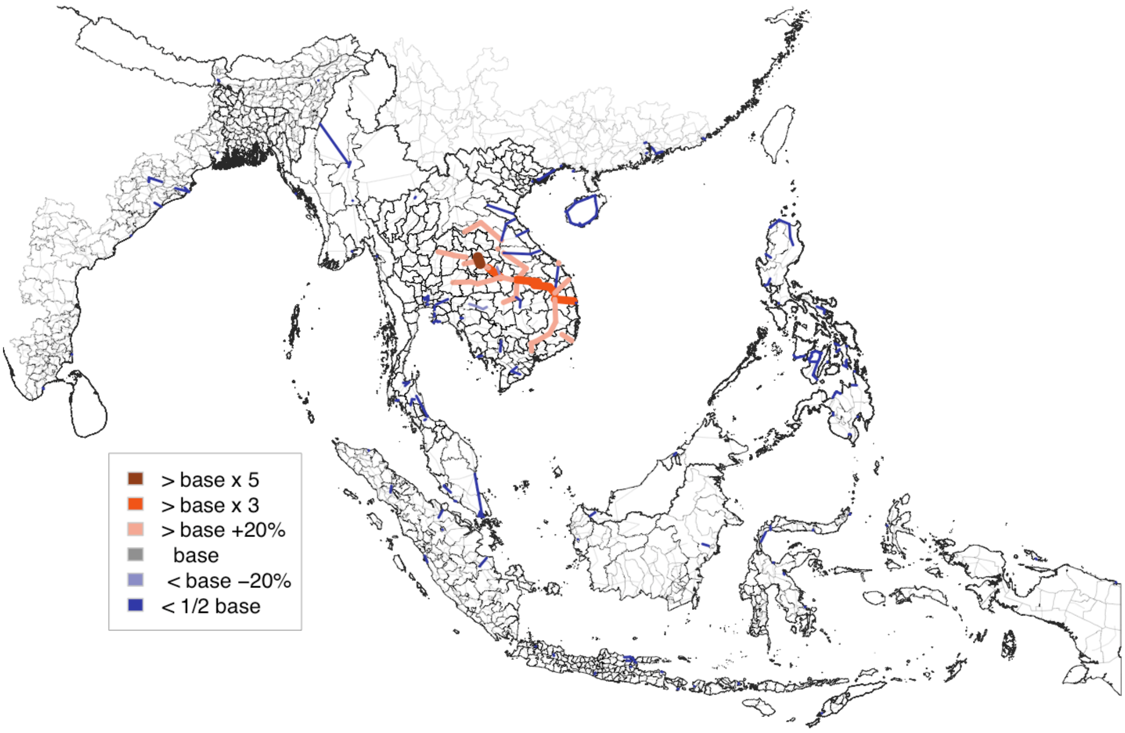


Figure E28: Gains in Regional GDP: ASEAN Highway No. 7C (10 years cumulative)

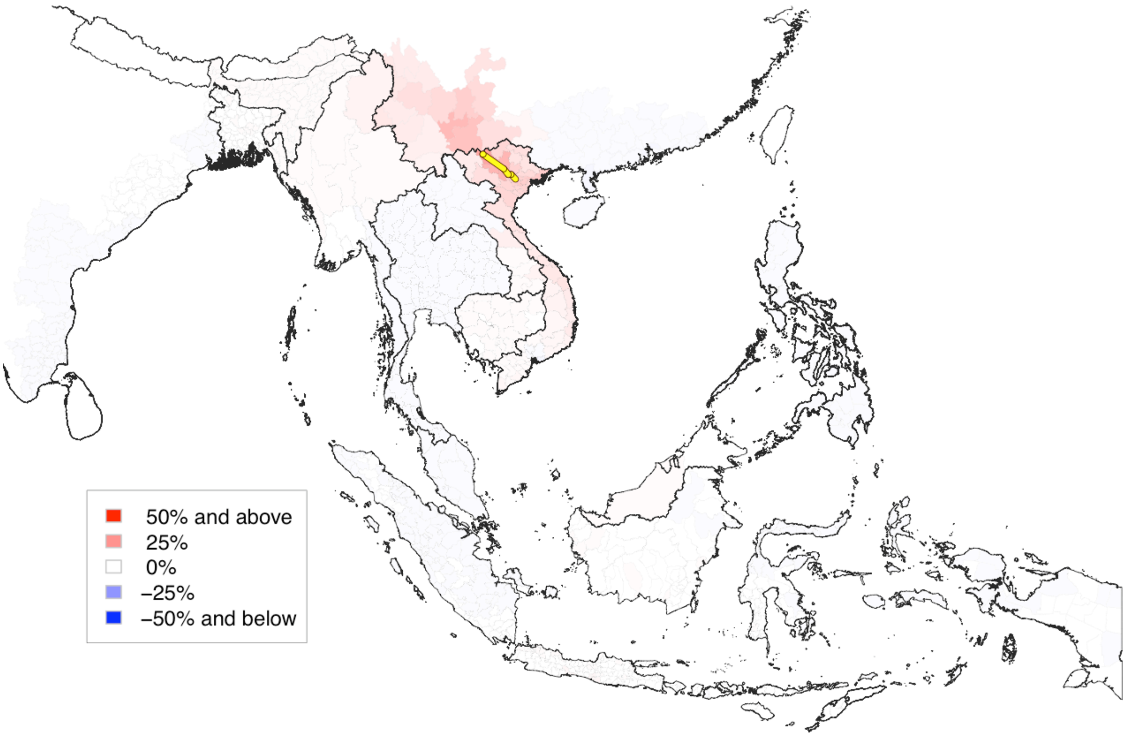


Figure E29: Changes in Traffic Volume by ASEAN Highway No.7C (10 years after)

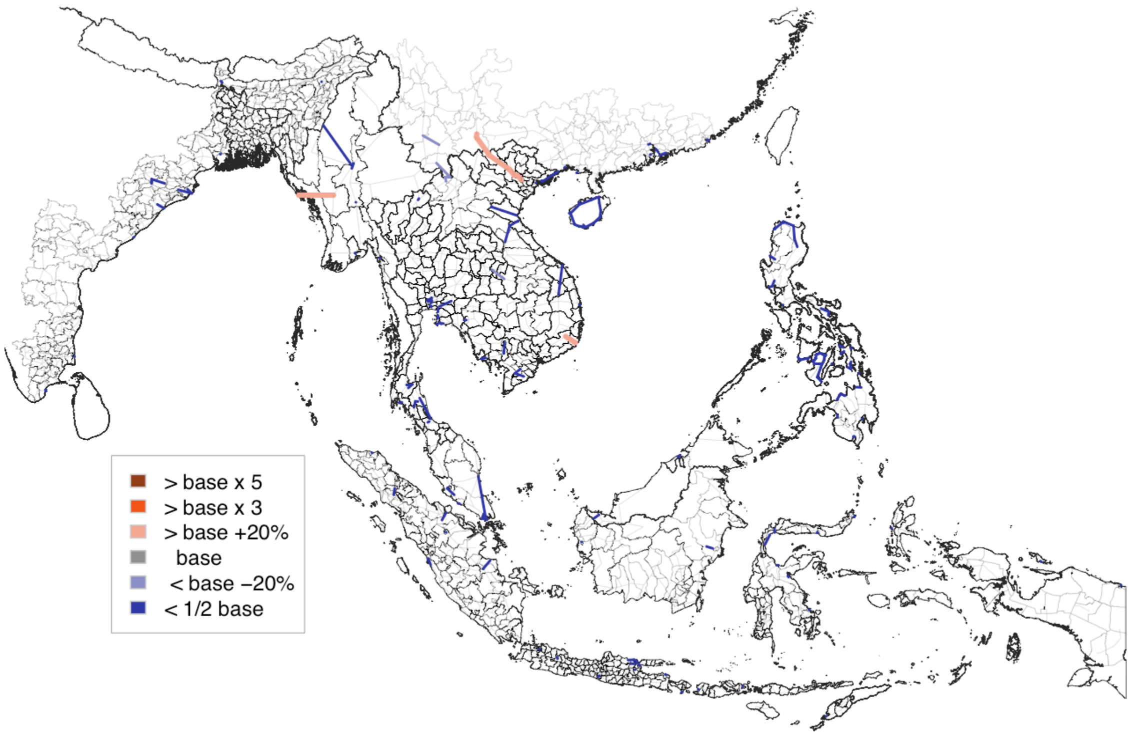


Figure E30: Gains in Regional GDP: ASEAN Highway No. 8 (10 years cumulative)

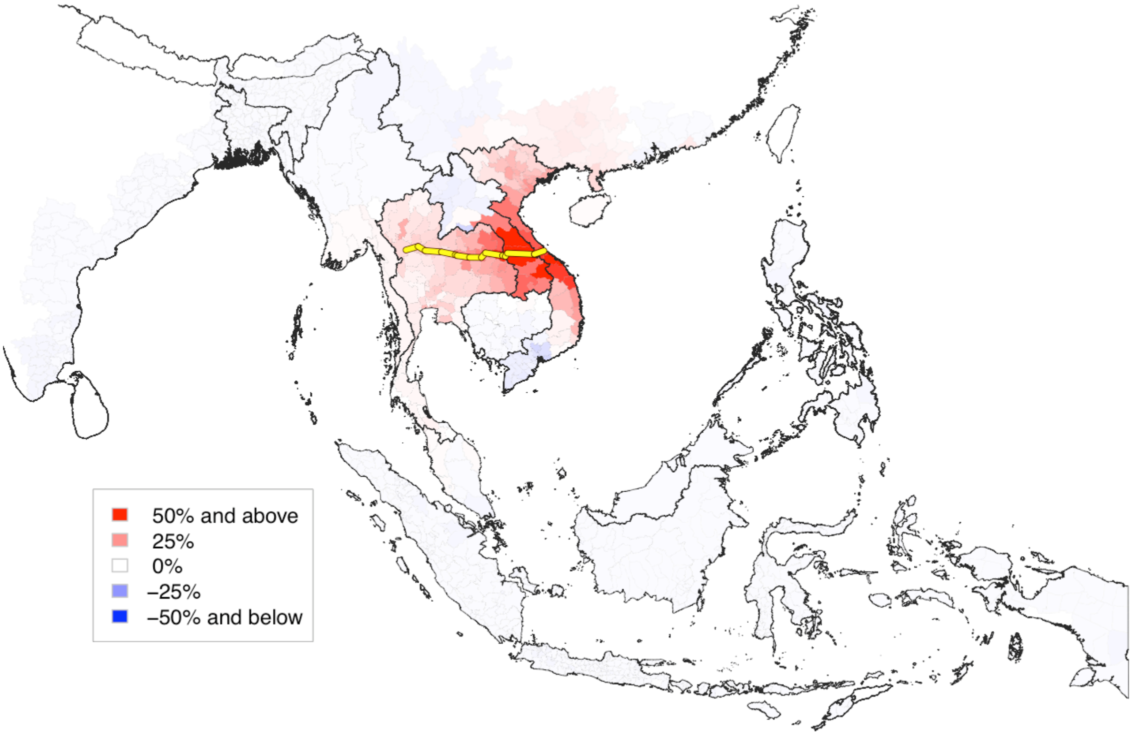


Figure E31: Changes in Traffic Volume by ASEAN Highway No.8 (10 years after)

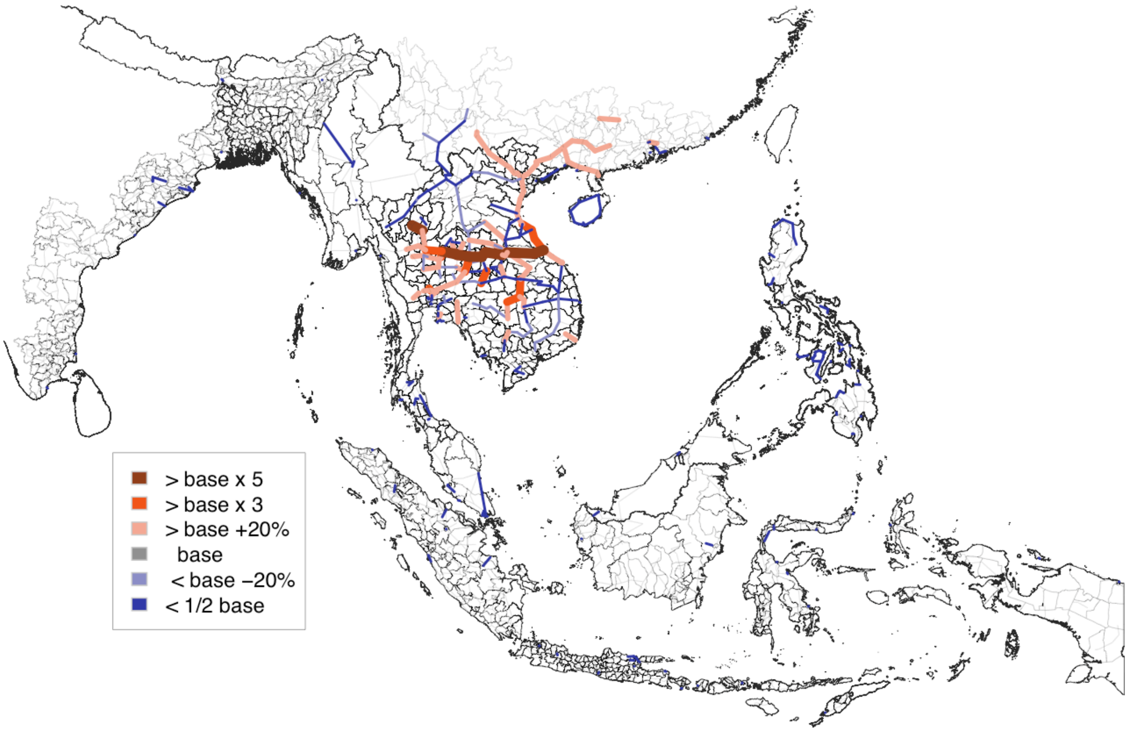


Figure E32: Gains in Regional GDP: ASEAN Highway No.9 (10 years cumulative)

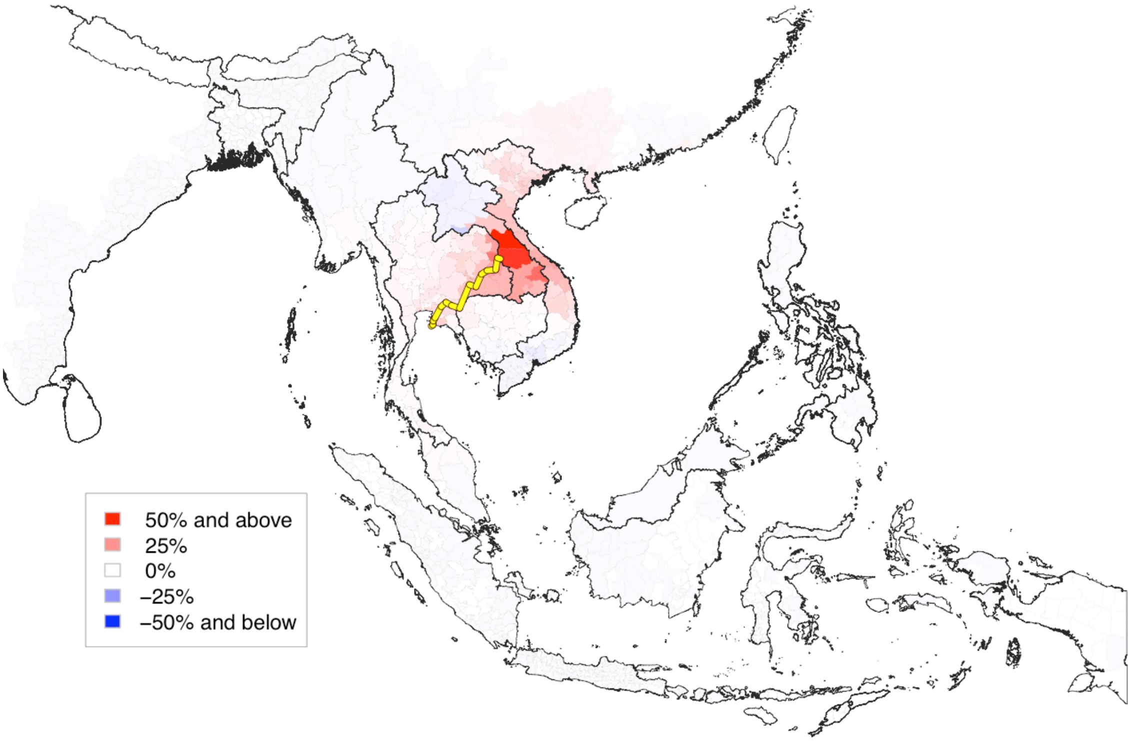


Figure E33: Changes in Traffic Volume by ASEAN Highway No.9 (10 years after)

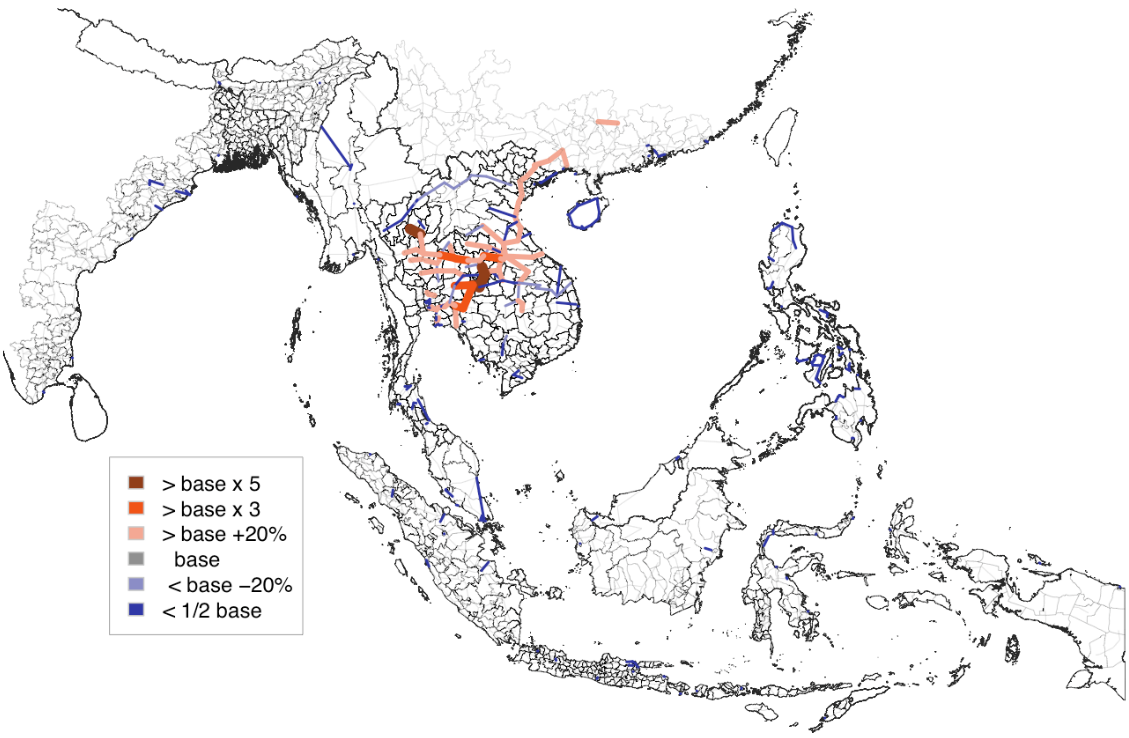


Figure E34: Gains in Regional GDP: ASEAN Highway No.9A (10 years cumulative)

Figure E35: Changes in Traffic Volume by ASEAN Highway No.9A (10 years after)

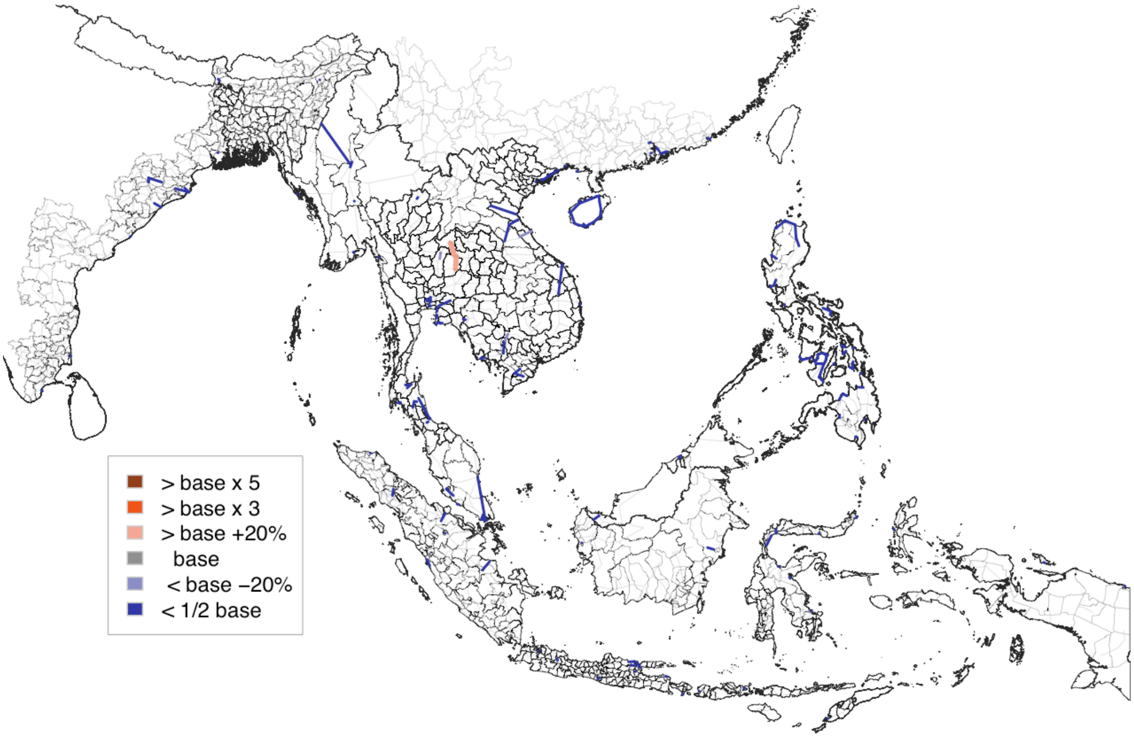


Figure E36: Gains in Regional GDP: ASEAN Highway No.10 (10 years cumulative)

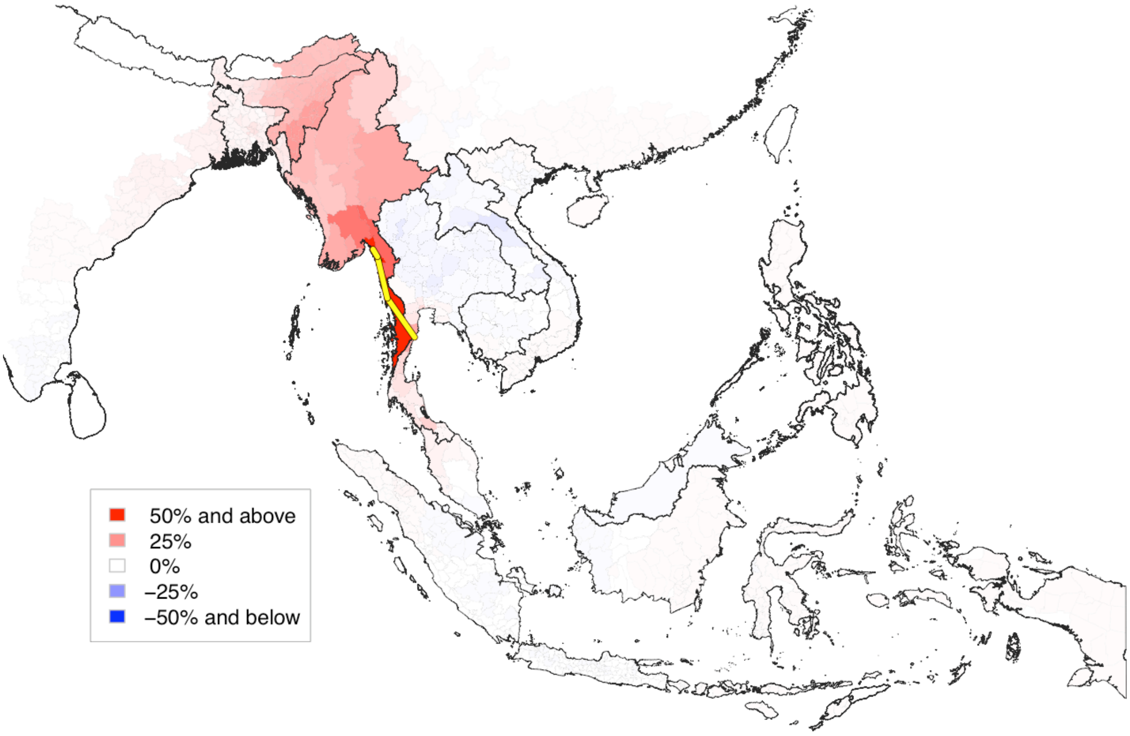


Figure E37: Changes in Traffic Volume by ASEAN Highway No.10 (10 years after)

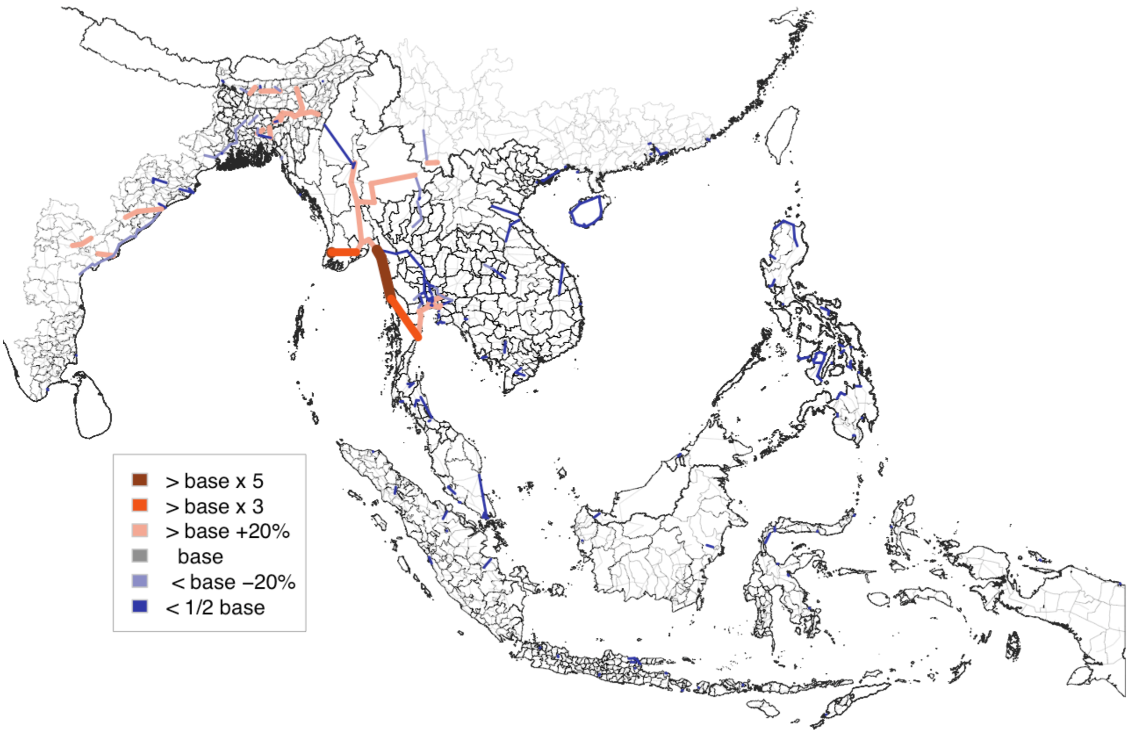


Figure E38: Gains in Regional GDP: ASEAN Highway No.11 (10 years cumulative)

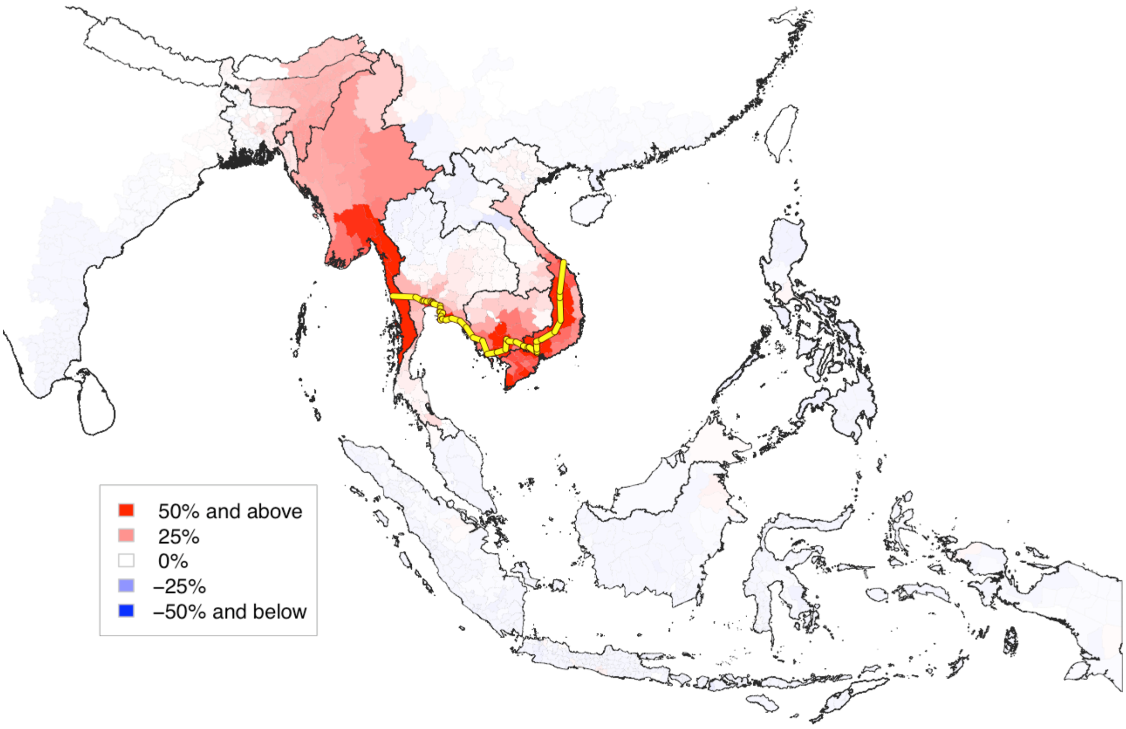


Figure E39: Changes in Traffic Volume by ASEAN Highway No.11 (10 years after)

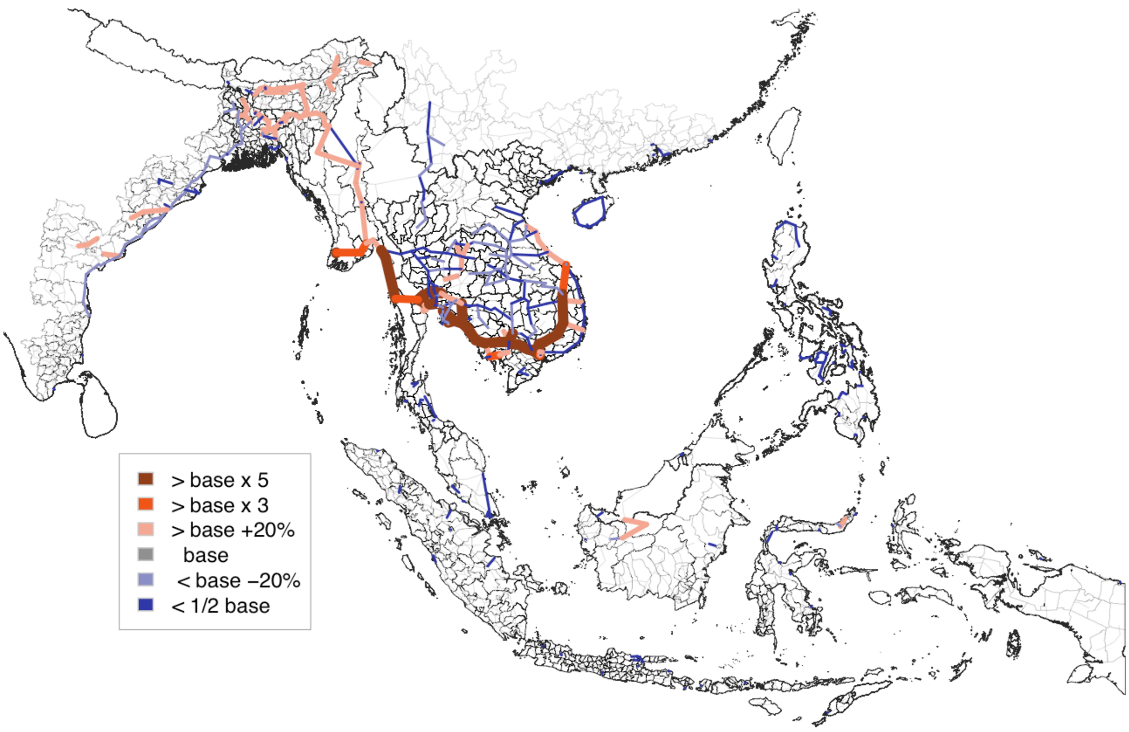


Figure E40: Gains in Regional GDP: ASEAN Highway No.12 (10 years cumulative)

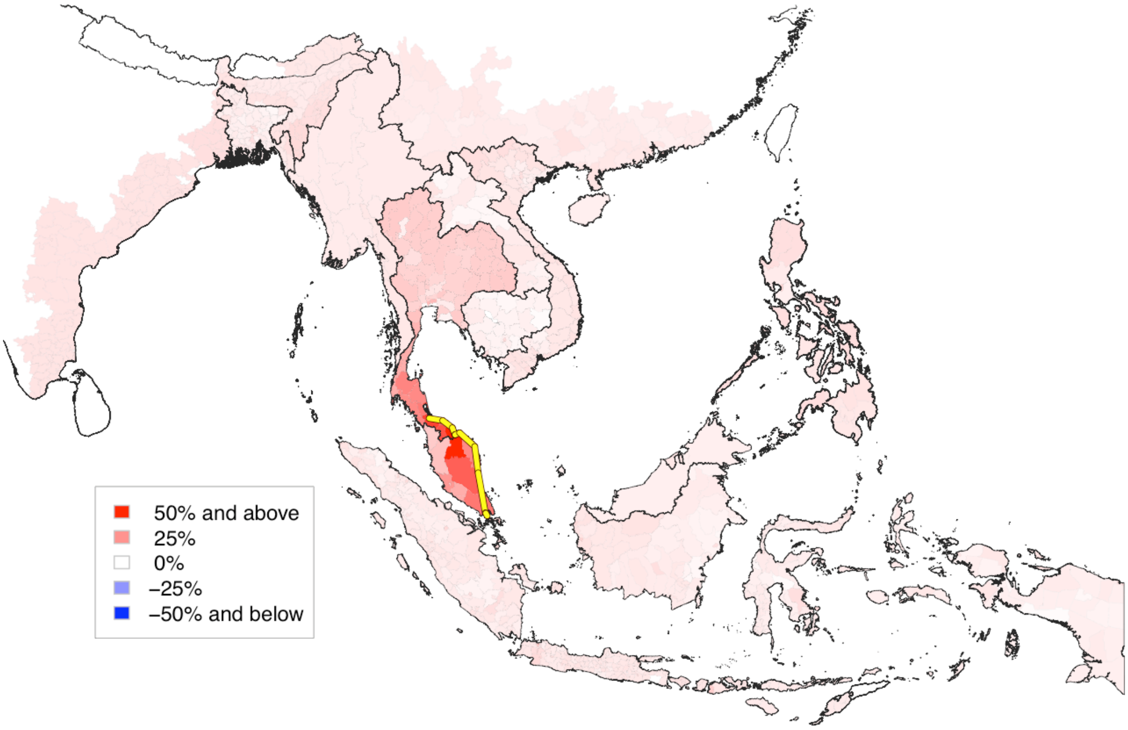


Figure E41: Changes in Traffic Volume by ASEAN Highway No.12 (10 years after)

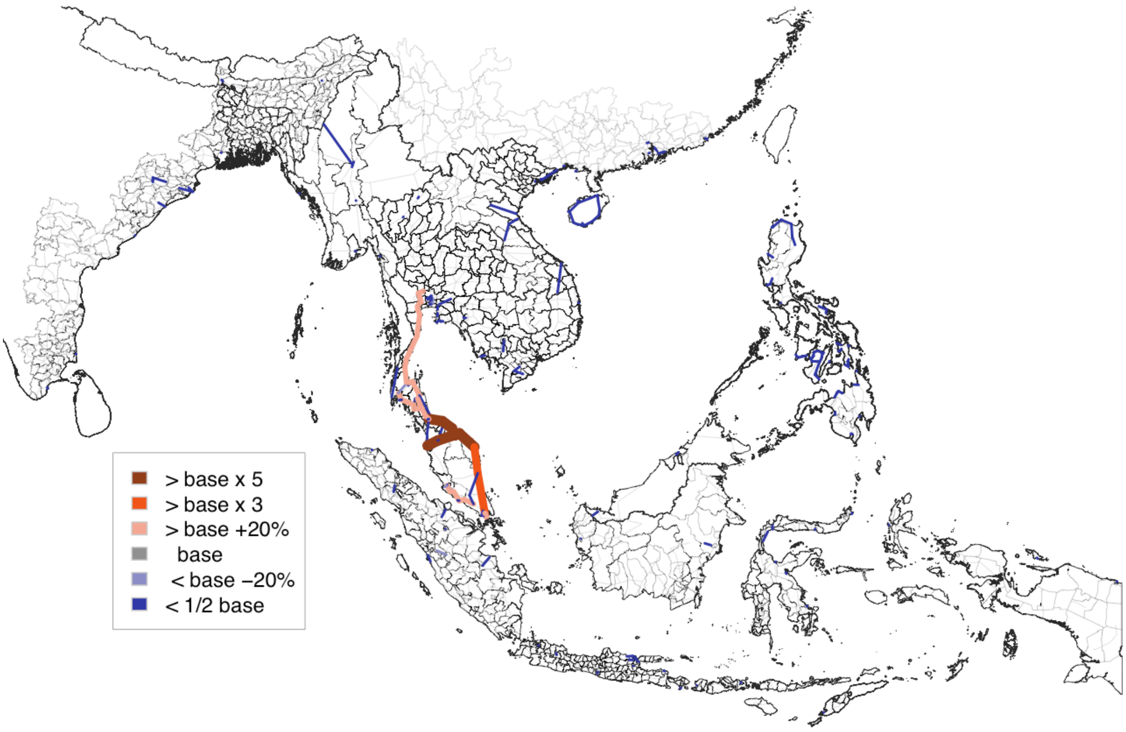


Figure E42: Gains in Regional GDP: ASEAN Highway No.13 (10 years cumulative)

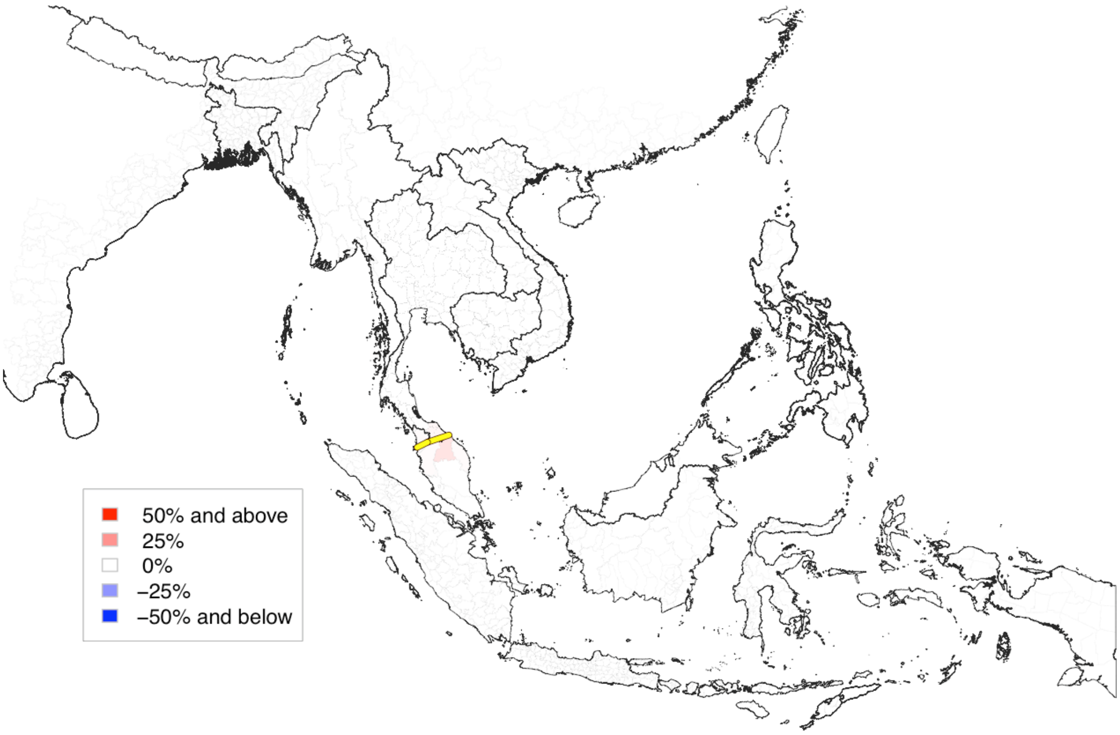


Figure E43: Changes in Traffic Volume by ASEAN Highway No.13 (10 years after)

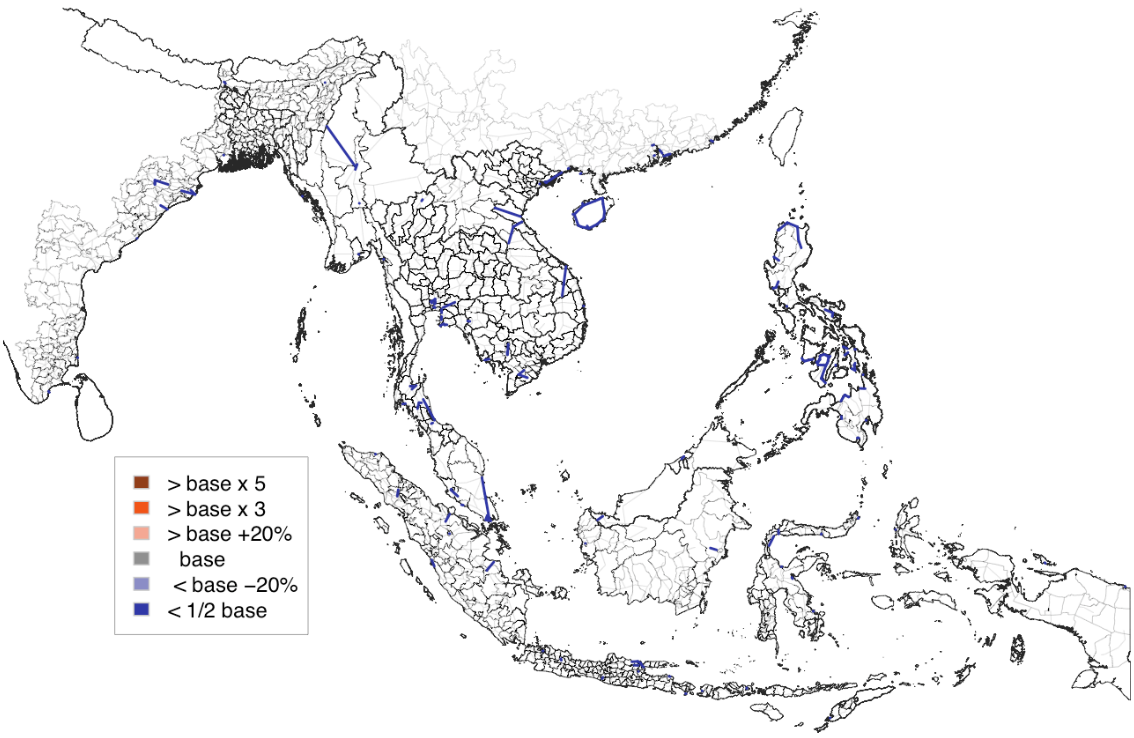


Figure E44: Gains in Regional GDP: ASEAN Highway No. 13A (10 years cumulative)

Figure E45: Changes in Traffic Volume by ASEAN Highway No.13A (10 years after)

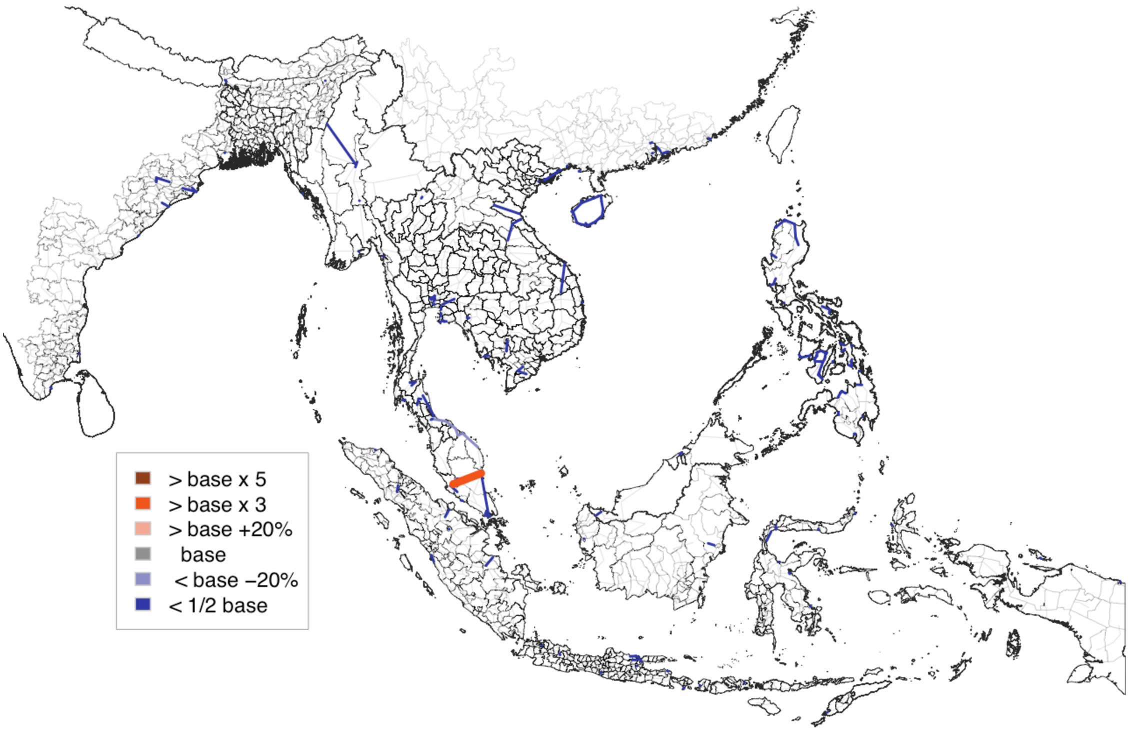


Figure E46: Gains in Regional GDP: ASEAN Highway No.13B (10 years cumulative)

Figure E47: Changes in Traffic Volume by ASEAN Highway No.13B (10 years after)

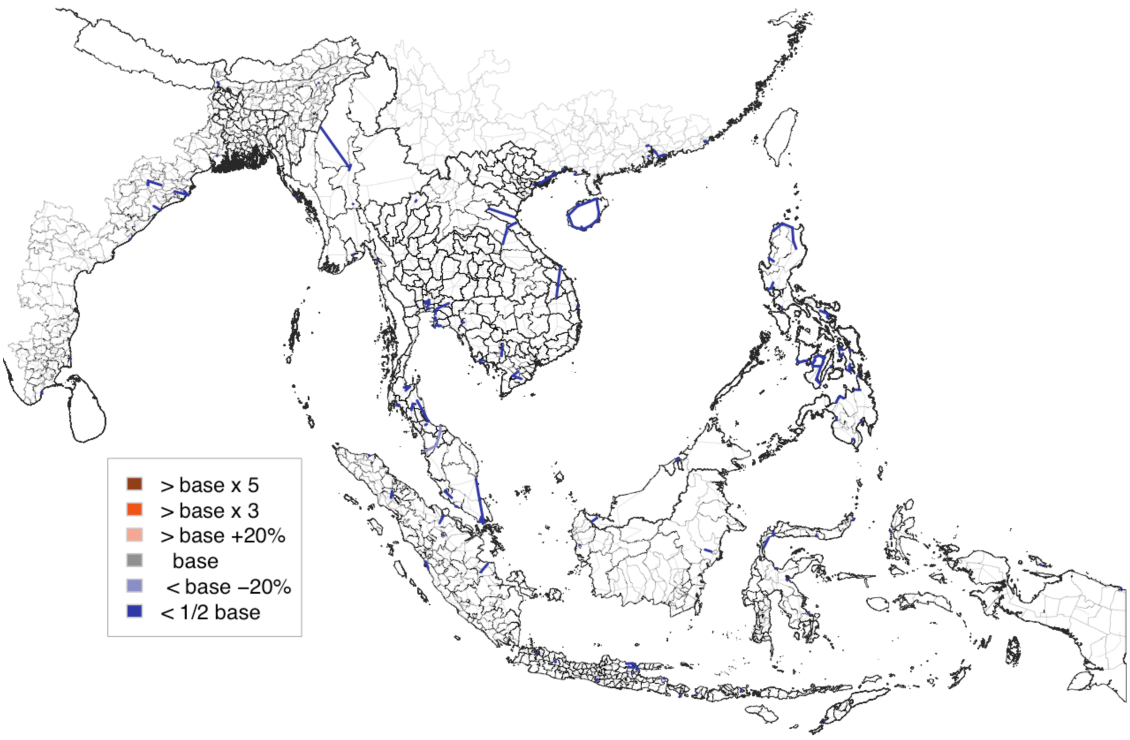


Figure E48: Gains in Regional GDP: ASEAN Highway No.13C (10 years cumulative)

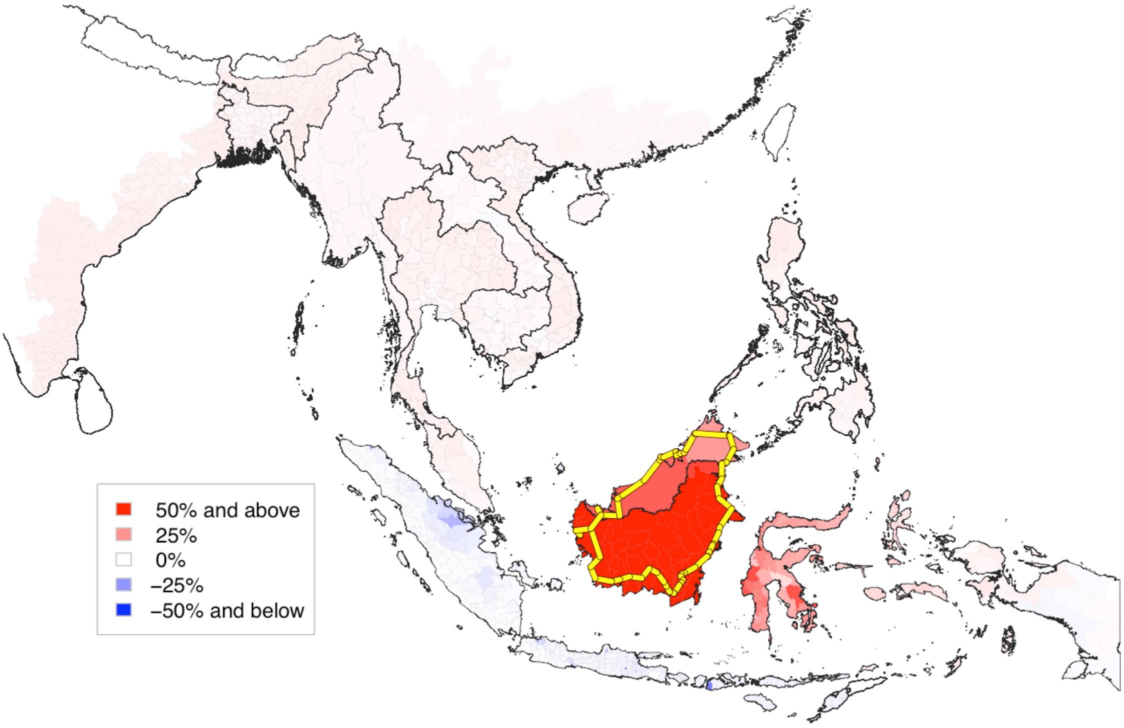


Figure E49: Changes in Traffic Volume by ASEAN Highway No.13C (10 years after)

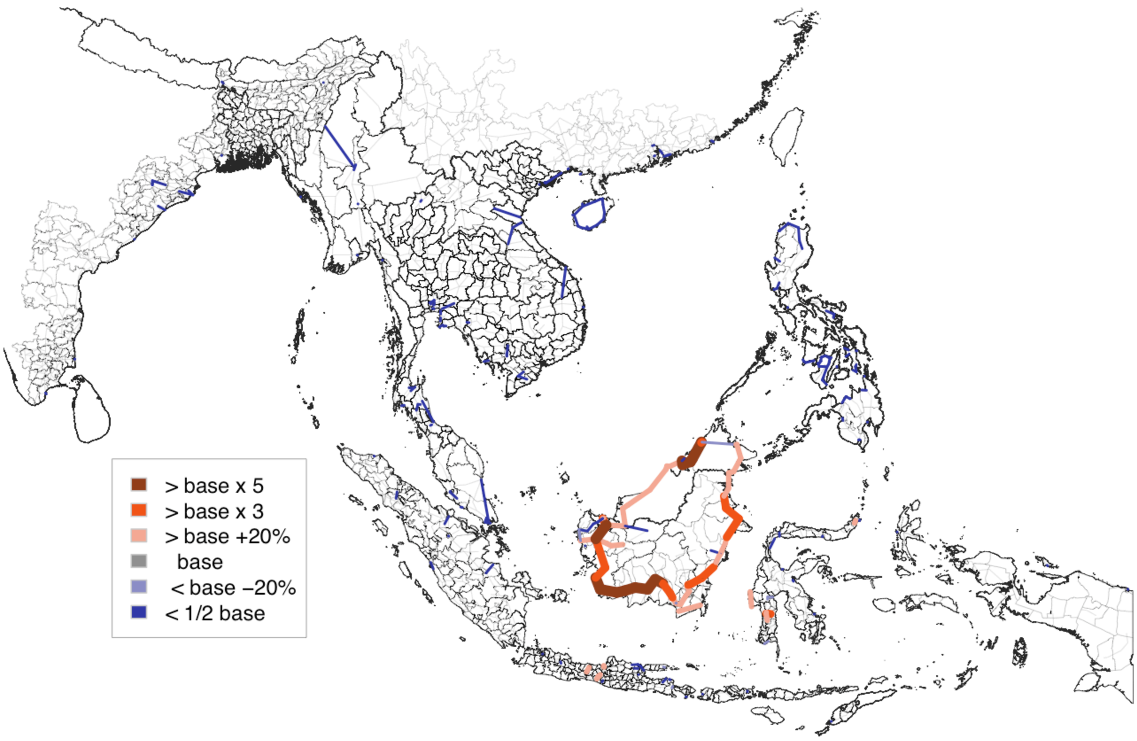


Figure E50: Gains in Regional GDP: ASEAN Highway No.14 (10 years cumulative)

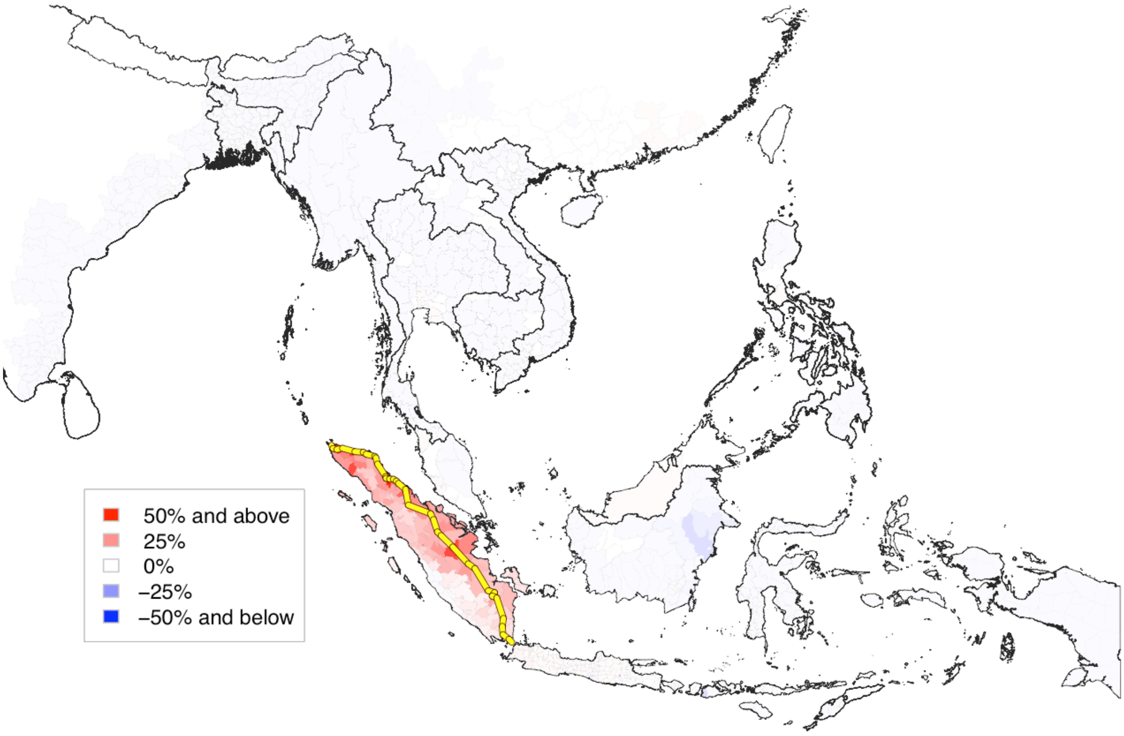


Figure E51: Changes in Traffic Volume by ASEAN Highway No.14 (10 years after)

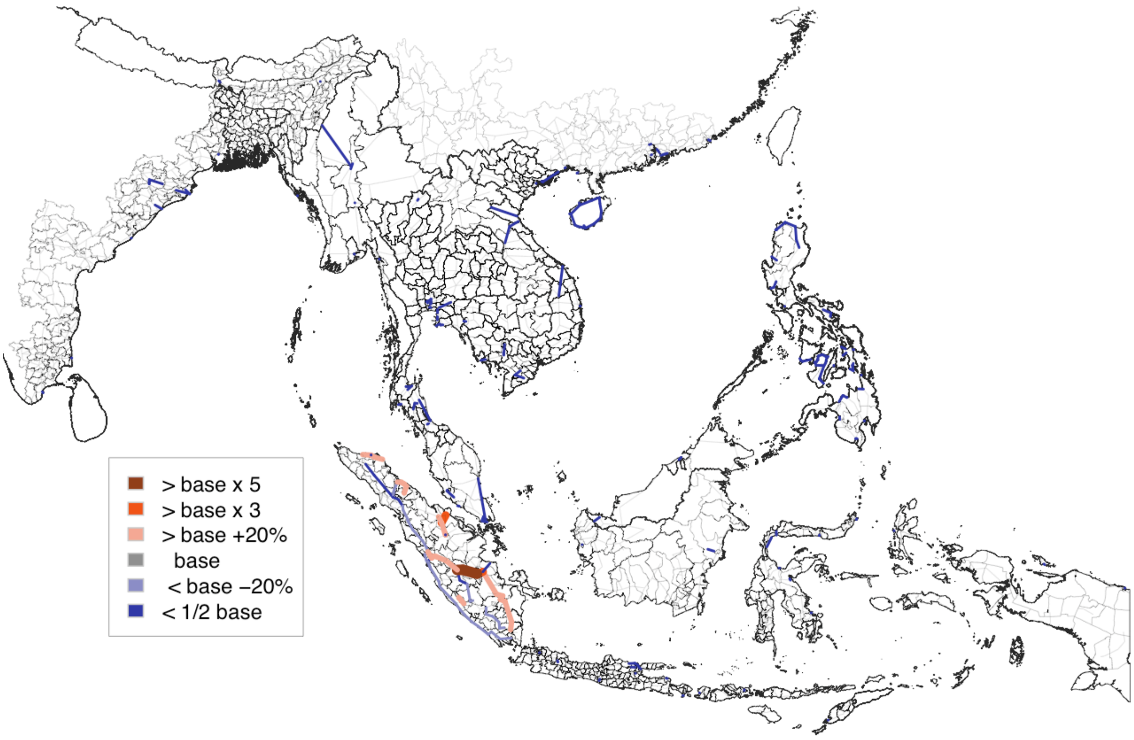


Figure E52: Gains in Regional GDP: ASEAN Highway No.15 (10 years cumulative)

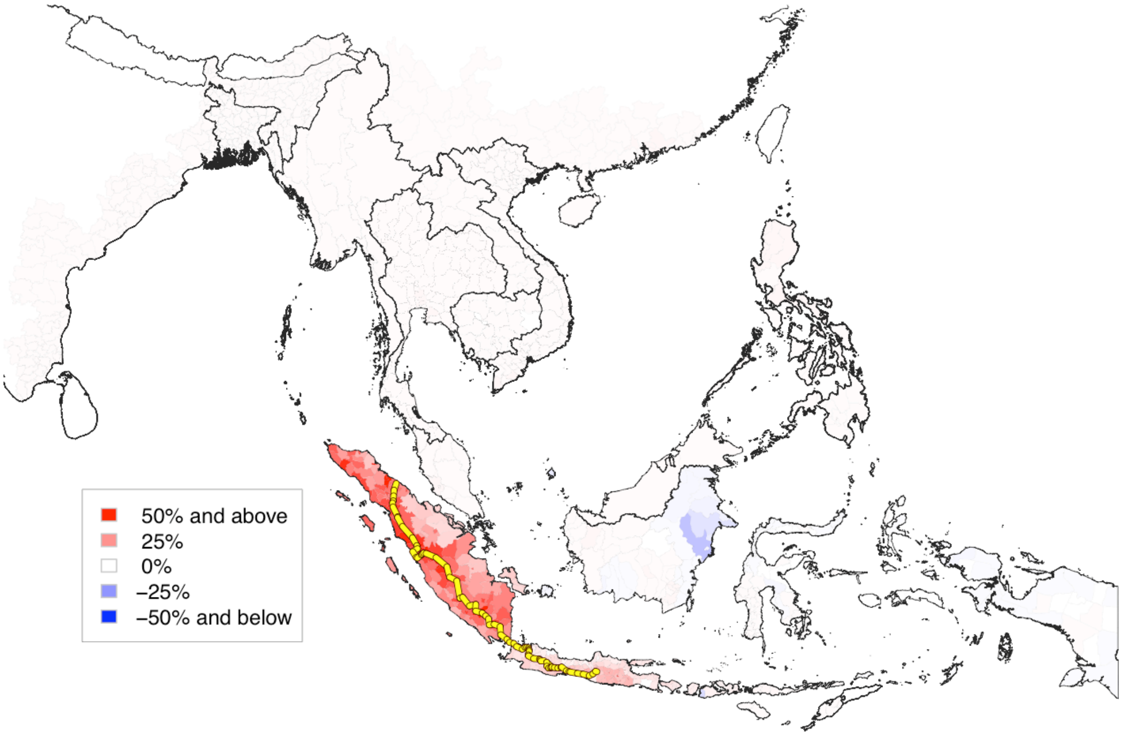


Figure E53: Changes in Traffic Volume by ASEAN Highway No.15 (10 years after)

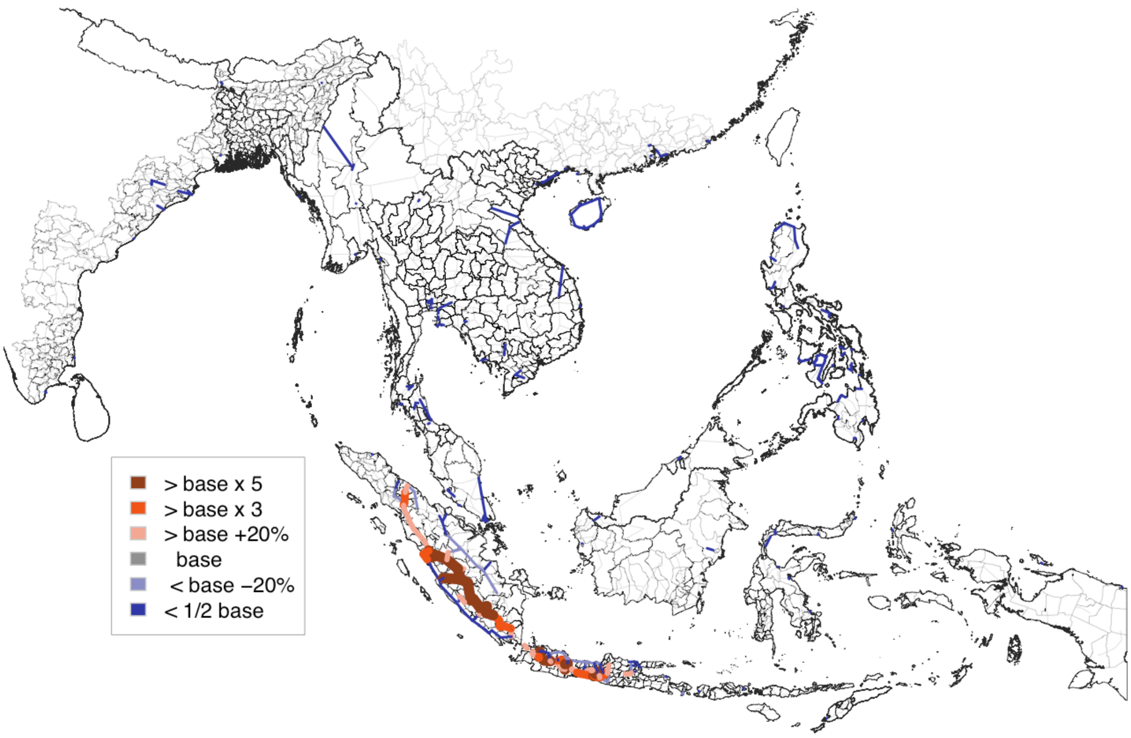


Figure E54: Gains in Regional GDP: ASEAN Highway No.16 (10 years cumulative)

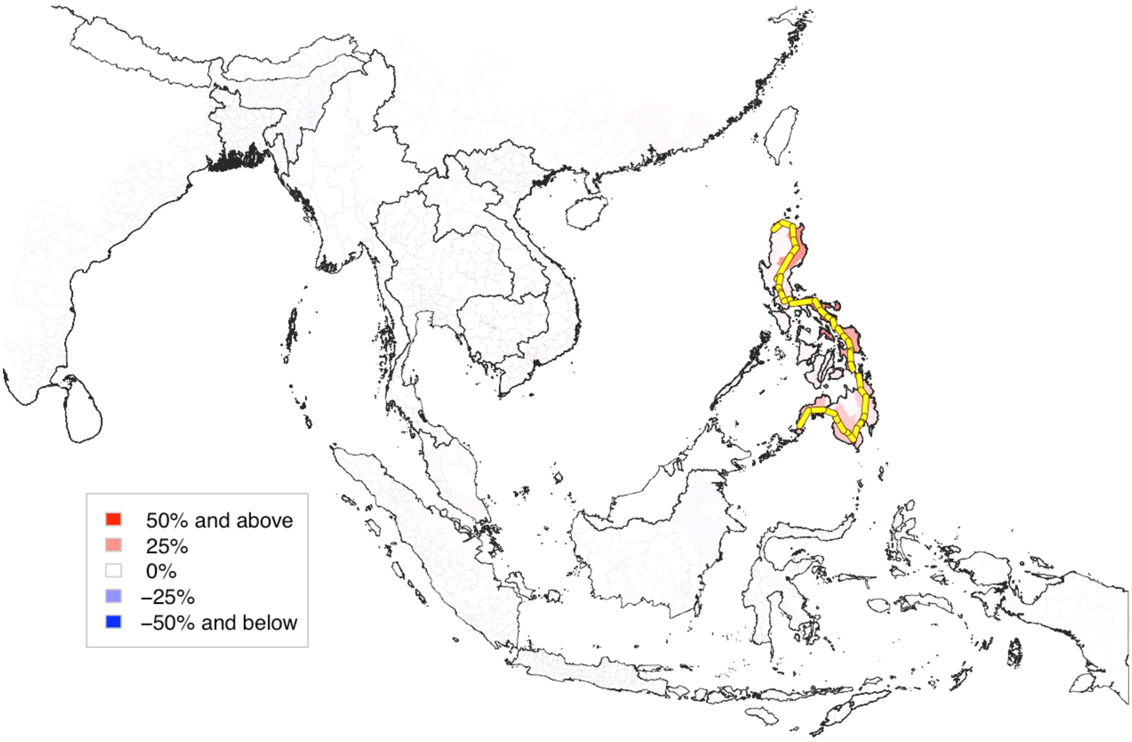
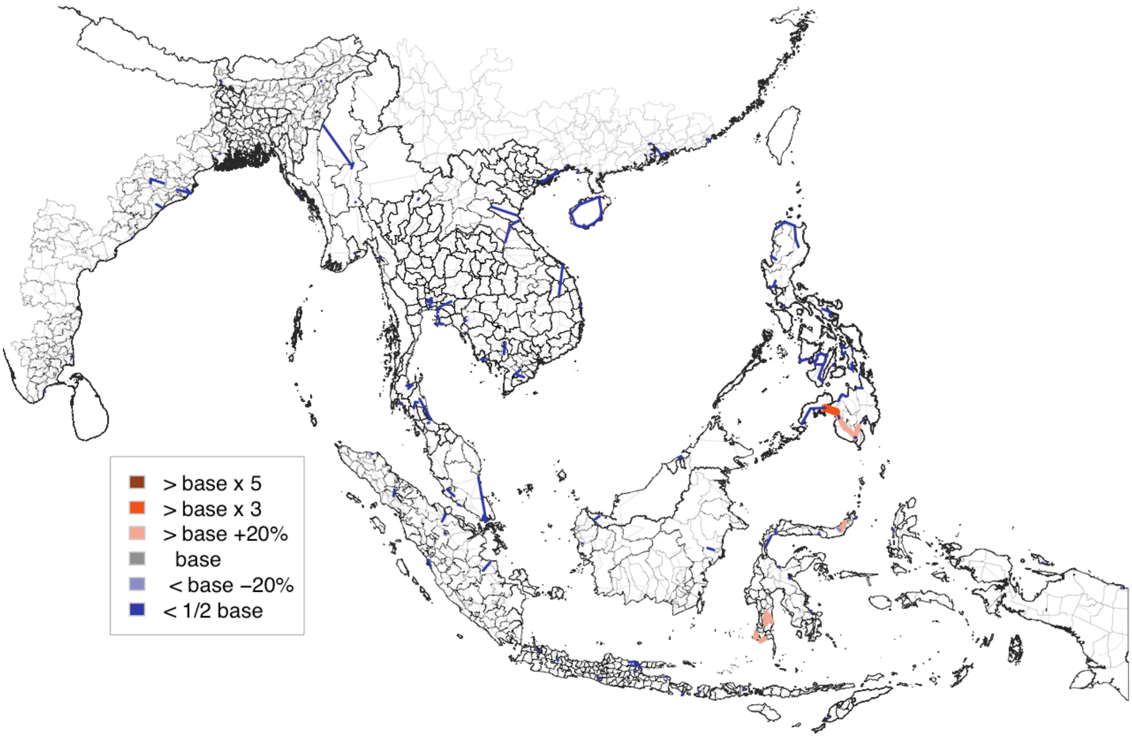


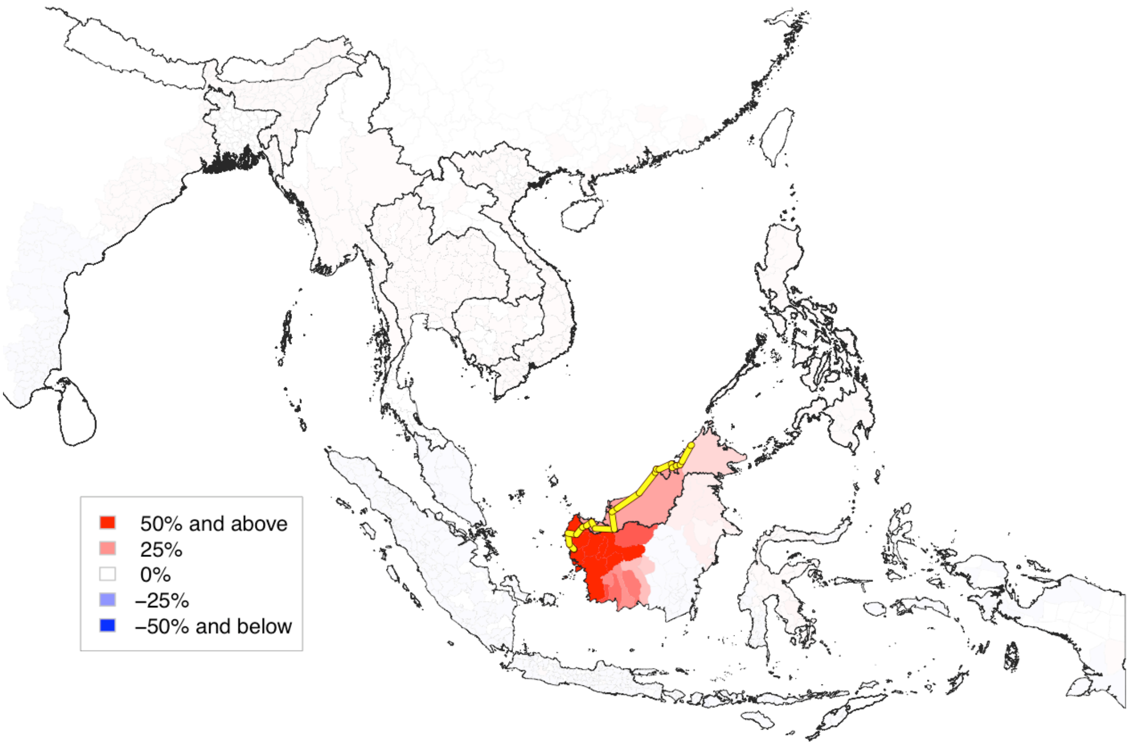
Figure E55: Changes in Traffic Volume by ASEAN Highway No.16 (10 years after)



E4. Pontianak - Kota Kinabalu Route

In this scenario, the route between Pontianak and Kota Kinabalu through Bander Seri Begawan is upgraded, " meaning cars can run on it at 60 km/h. In addition, border costs (time and money) are are reduced to two hours and one-fifth of the original baseline scenario.The economic effects of the development of Pontianak-Kota Kinabalu route are depicted in Figure E61.

Figure E56: Gains in Regional GDP: Pontianak - Kota Kinabalu (10 years cumulative)



E5. "Ring Route" around Borneo/Kalimantan

In this scenario, the land routes of Jakarta-Surabaya, and Manila-Davao are upgraded, " meaning cars can run on it at 60 km/h. In addition, the sea routes of Manila-Singapore-Jakarta and Davao-Manado-Balikpapan-Surabaya are also upgraded, meaning the speed is doubled and border costs (time and money) are reduced to the half of the original baseline scenario. The economic effects of the development of the "Ring" route are depicted in Figure E62.

Figure E57: Gains in Regional GDP: "Ring Route" around Borneo/Kalimantan (10 years cumulative)