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Agglomeration and Dispersion in China and ASEAN: a Geographical Simulation Analysis

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Abstract. Spatial designing of economic development with enhancing connectivity has become essential to pursue both sustained growth and the narrowing of development gaps. The issue of agglomeration and dispersion in China and its neighboring countries is an example of requiring such an approach. This paper introduces the Geographical Simulation Model (GSM) based on the new economic geography setting and presents illustrative simulations on Asian Highway No. 3 and Kyaukpyu deep sea port development in order to analyze the economic implication of developing hard and soft infrastructure as well as lowering national border barriers for inclusive growth at the sub-national level.

Key words: New economic geography, computable general equilibrium models, logistics infrastructure, border effect, inclusive growth

JEL Classification: O53, O18, R13

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1. Introduction

China and surrounding East Asia have continuously been a sustained growth center for decades and have achieved a substantial reduction in poverty and the formation of middle-income population. Economic integration, both *de facto* and *de jure*, has also made considerable progress in East Asia. Production networks in East Asia, particularly in the manufacturing sector have been a top runner of the second unbundling in the world, and the formation of free trade agreements has also been active. At the same time, the inclusiveness of economic growth has increasingly been a serious concern. The issues of inclusiveness are multifaceted; they at least have three dimensions, spatial, industrial, and societal. The inland-coastal disparity in China is one of the salient examples that present these three dimensional inclusiveness issues. How to achieve a reasonable level of inclusiveness together with strong economic growth and economic integration has been a big challenge for China and East Asia.

Despite strong demand for policy research, our analytical tools for spatial inclusiveness have not been well developed yet. Before hastily jumping into "social policy" directly to redistribute income, we should consider the possibility of applying "economic policy" to make the market mechanism work and achieve narrowing development gaps. In order to do so, we must deepen our understanding on the implication of enhancing institutional and physical connectivity for geographical inclusiveness in a spatial setting.

The Geographical Simulation Model (GSM) is a powerful analytical model to select, prioritize, and combine various trade and transport facilitation measures (TTFMs) in East Asia in considering the location of population and industries. It is a unique simulation model developed by Economic Research Institute for ASEAN and East Asia (ERIA) and the Institute of Developing Economies, JETRO (IDE-JETRO) and is utilized to simulate the future growth of East Asia at the sub-national level (ASEAN 2010 and ERIA 2010). The model includes sub-national data with 1,560 regions, more than 3,000 nodes, and 5,000 routes, comprised of road, sea, air, and rail transport networks. It takes into account physical transport costs, physical shipment and transshipment time, as well as tariff and non-tariff barriers. Within the model, firms and households are engaged in economic activities and choose their preferred locations based on their profits and real income.

The model is a kind of computable general equilibrium (CGE) models with new economic geography (NEG) setting, following the models of Krugman (1991) and Fujita, *et al.* (1999). Forslid, *et al.* (2002a) and Forslid, *et al.* (2002b) constructed CGE models with NEG setting and conducted analyses on expanding economic integration in Europe. Differing from the models for European countries, our simulation model includes hard as well as soft infrastructure development, based on the compelling reality that East Asian countries have considerable room for constructing and upgrading hard infrastructure for better domestic and international connectivity.

As for the economic integration of East Asia, several GTAP (Global Trade Analysis Project)-based or -variant models have been developed and tested by Siriwardana (2003), Urata and Kiyota (2005), Francois and Wignaraja (2008), and Kawai and Wignaraja (2008). However, because GTAP-based models only have zero or a limited number of sub-national regions and no NEG settings, they cannot properly illustrate the agglomeration and dispersion of economic activities, economic impacts of hard infrastructure projects such as road or port development, or economic impacts of the combinations of hard and soft infrastructure development, especially at the sub-national level. Only our simulation model can estimate possible impacts of hard infrastructure projects in a spatial setting with economic interactions among people, firms, sub-national regions and countries.

For China and its neighboring countries including ASEAN, our primary concern is on the balance between agglomeration and dispersion of economic activities and the implication of national border barriers. To highlight these aspects of development strategies, we conduct simulations on two illustrative scenarios pertaining to connectivity enhancement for China and its neighboring countries. One is the intra-country connectivity enhancement, the improvement of Asian Highway No. 3 (AH3) between Shanghai and Kunming. The other is the enhancement of cross-border connectivity, the strategic Kyaukpyu deep sea port development in Myanmar. Key conclusions of our study are twofold. First, AH3 will accelerate economic growth as well as narrowing the development gaps of China though the economic impact on the whole China is relatively small. Our simulation results show that improving a section of the Asian Highway No. 3 from Shanghai to Kunming will raise Kunming City's gross regional development product (GRDP) in 2030 by 5.21% while it would raise the whole China's GDP by 0.32% over the same period. It is because regions benefitted by the road improvement are geographically limited. Some other regions far from the highway experience outflows of firms and workers so that negative impacts cancel out some portion of positive impacts of the highway. Second, the Kyaukpyu deep sea port project together with related national border connectivity enhancement may not contribute to GDP growth of the whole China much but will substantially reduce development gaps within China by providing Western China a new trade gateway to India and EU, stimulating economic activities in the whole part of Western China, and reducing excessive agglomeration in China's coastal area.

The rest of this paper is organized as follows: in section 2, the model and data of the simulation are presented. Section 3 presents and discusses simulation results. The final section summarizes the implication of the simulations.

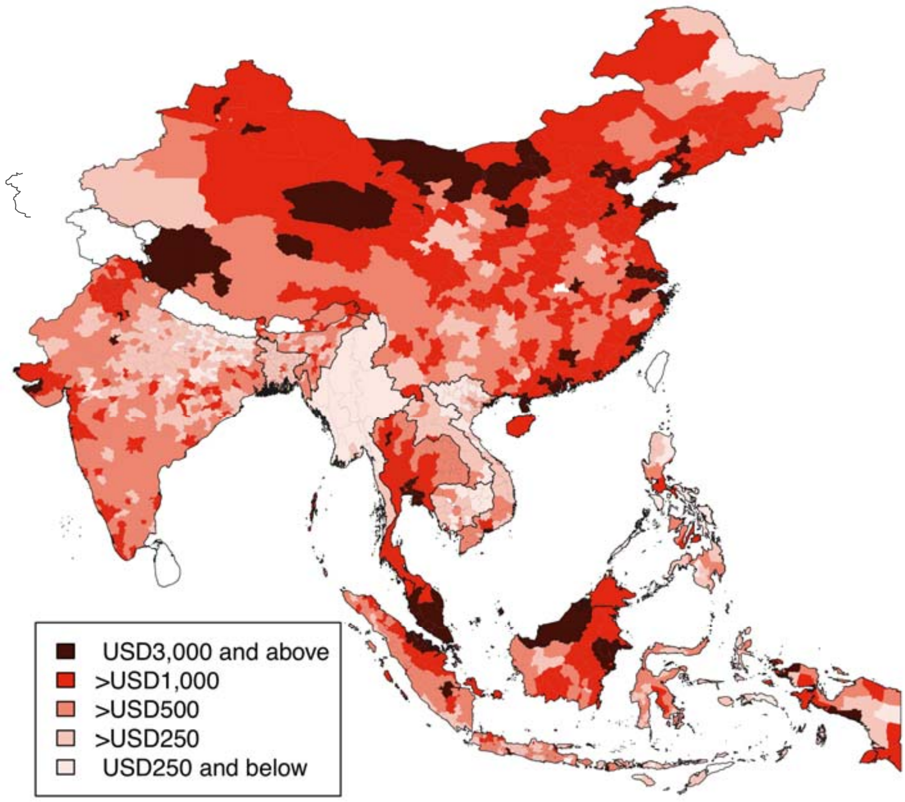
2. Basic Structure of GSM and the Baseline Scenario[2]

GSM, which is backed up by a huge dataset in the NEG structure, makes it possible to simulate the dynamics of population and industries for a long run and to analyze the effects of the improvement of connectivity. NEG consists of various elements of agglomeration forces, such as economies of scale in production site, and dispersion forces, such as transport costs and production differentiation, and thus tells us why and how economic activities agglomerate. GSM provides policy diagnosis on how we can utilize agglomeration forces and dispersion forces in the region, what sorts of policy measures contribute to regional integration and further domestic/regional economic growth, and to what extent we can pursue higher economic growth and narrowing the development gaps in parallel. In fact, even though *de facto* economic integration and *de jure* institutional liberalization have advanced in East Asia, economic activities with

[2] The model is a variation of Puga and Venables (1996) modified to fit the East Asian context. For the details of the model and data construction, see Kumagai *et al.* (2011).

sophisticated production networks still remain in limited areas, leading to huge development gaps across the region, not only among countries but also within a country (Figure 1). For instance, in China, coastal regions with industrial clusters achieve high per capita GRDP, and a few inland regions having natural resources also enjoy high per capita income. On the other hand, other inland regions lag behind. Much room is left to improve physical connectivity as well as institutional connectivity in order to control agglomeration and dispersion forces and pursue the narrowing of development gaps.

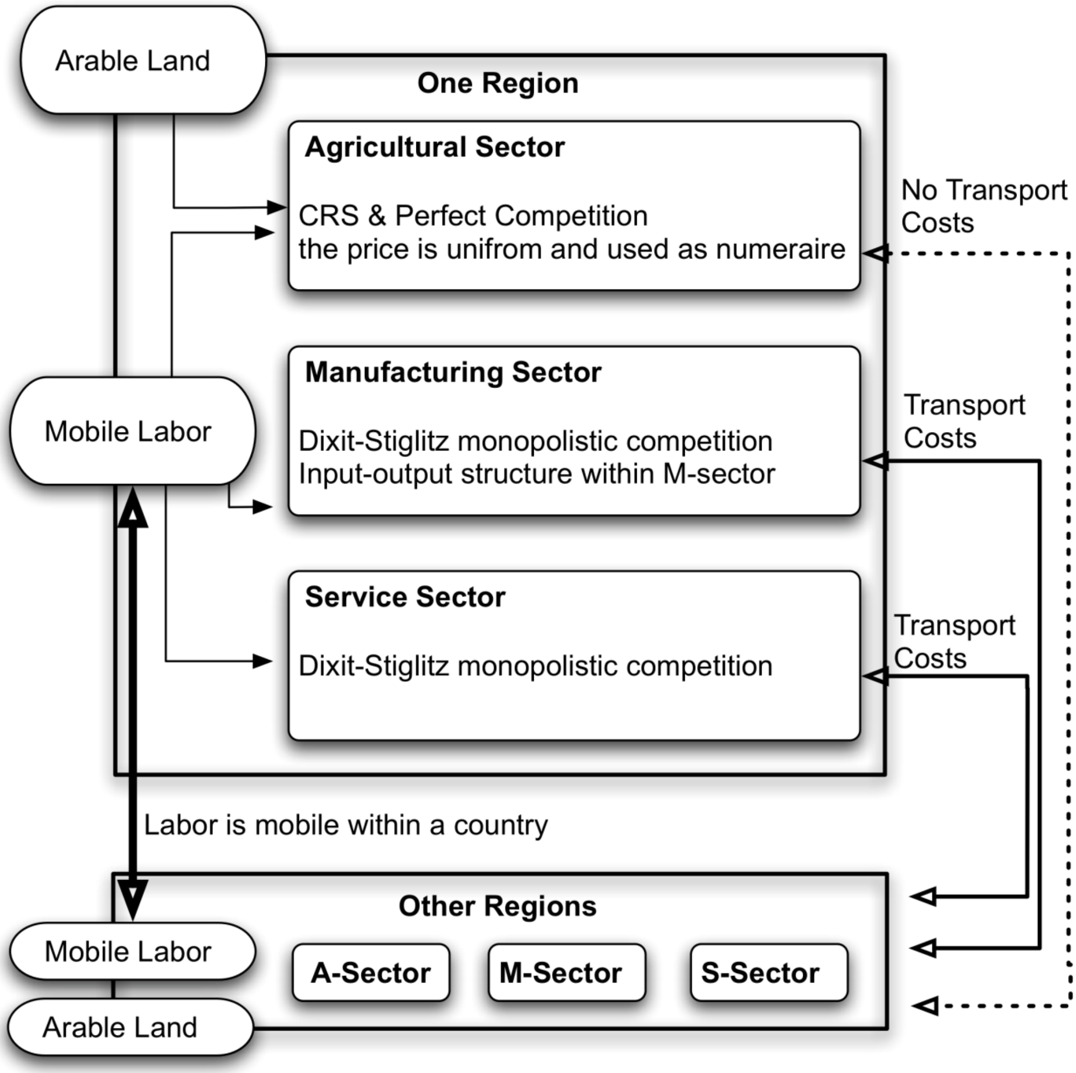
Figure 1: GDP per capita (2005)



Source: Authors.

The basic structure of our GSM is shown in Figure 2. We have three sectors, namely agriculture, manufacturing, and services, and the manufacturing sector is divided into five sub-sectors. The agricultural sector produces a homogeneous good using a constant-returns-to-scale (CRS) technology under perfect competition. Firms in the manufacturing and services sectors produce differentiated products/services among a mass of varieties of manufactured goods/services using an increasing-returns technology under monopolistic competition. While the services sector only uses labor inputs to produce services, manufacturing firms use labor and differentiated manufactured goods, and agricultural firms use labor and land as inputs. All products in the three sectors are tradable. Transport costs for the agricultural good are assumed to be costless, both domestically and internationally. Note that the price of an agricultural good is chosen as the numéraire so that the price of the agricultural good is the same in all the regions. Transport costs of manufactured goods and services are assumed to be of the iceberg type, i.e., if one unit of product is sent from one location to another, only a portion of the unit arrives. Transport costs within the same region are considered to be negligible. We allow labor migration within a country and among the industrial sectors with friction. People move to their favored region or industrial sector to seek higher real wages. However, the movement is with friction so that real wage gaps cannot be resolved in a single period.

Figure 2: Basic Structure of the Simulation Model

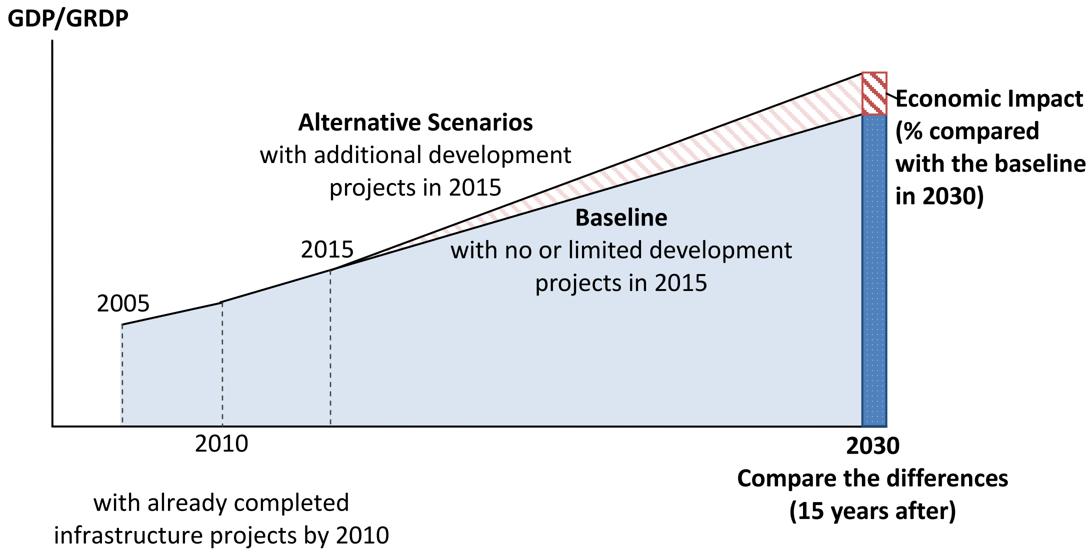


Source: Kumagai *et al.* (2011)

GSM includes the average speed of each transport mode based on survey results of ERIA's innovation and agglomeration projects (Limskul 2009 and Intarakumnerd 2010) and the ASEAN Logistics Network Map by JETRO (JETRO 2008 and 2009). The basic speed of land transport is set at 38.5 km/h. In addition, we assume that the speed of the following highways is 60km/h: G1 – G7 in China, in Thailand (excluding the area surrounding Bangkok), between Bukit Kayu Hitam and Singapore via Kuala Lumpur, between Vientiane and Pakse, and between Sisophon and Bavet. The speed passing through mountainous areas is set at a half of the basic. As for sea transport, the average speed is set at 29.4 km/h for international-class routes, and at a half of that for other routes. For air transport, the average speed is set at 800 km/h between each country's primary airports and at 400 km/h for other routes. The average speed of rail transport is set at 19.1 km/h. Firms select and sometimes combine different transport modes among road, rail, sea and air transport by calculating transport costs based on physical transport costs and time costs.

We change settings in trade and transport facilitation measures (TTFMs) and see the difference in GDP/GRDP between the baseline scenario and an alternative scenario, 15 years after the implementation of specific TTFMs (Figure 3). TTFMs include the development of physical infrastructure (PI), reduction in non-tariff barriers (NTBs), and reduction in tariffs. We also separate the reduction in NTBs into Customs Facilitation (CF) at the borders/ports/airports and other NTBs. Tariff reduction and the latter part of NTB reduction are called a reduction in policy and cultural barriers (PCBs). Parameters of PCBs estimated by trade data indicate that considerable barriers exist between China and its surrounding countries. We adopt the similar approach to Anderson and van Wincoop (2003), which reveals that a tax equivalent barrier between the United States and Canada is about 170%, and find, for example, that tax equivalent policy and cultural barrier of China in food processing industry, reaches 1,619%.

Figure 3: Image Diagram: Difference between the Baseline Scenario and Other Alternative Scenarios



Source: Authors.

In sum, our simulation model can estimate possible impacts of seven settings of TTFMs and other local development measures (LDMs) in the model as follows:

(1) (PI) Raising the speed of road, air, sea, and rail transport for each section
(2) (PI) Reducing physical transport costs per kilometer for each section
(3) (CF) Reducing transshipment times at each border, port, and airport
(4) (CF) Reducing transshipment costs at each border, port, and airport
(5) (PCBs) Reducing other non-tariff barriers, including:
- Streamlining the official procedures before shipping
- Simplifying or improving transparency in sanitary and phytosanitary, technical barriers to trade, and intellectual property rights measures
- Eliminating trade quotas.

(6) (PCBs) Decreasing/eliminating tariffs
(7) (LDM) Technological parameters on local economic performance, including:
- Enhancing education level / skill level
- Improving logistics infrastructure within the region
- Improving communications infrastructure within the region

- Raising capacity for electricity and water supply
- Stimulating usage of better equipment in firms
- Raising the utilization ratio / efficiency of this infrastructure and equipments

In the simulation model, TTFMs take a form of lowering transport costs or trade barriers on specific routes between regions. Reducing transport costs improves the profitability of firms and thus the wages of workers. Improving profitability and wages induces the movement of firms and households to the regions with higher expected profits and higher real wages. The movement of firms and households changes the relative attractiveness and competitiveness across regions and thus induces further movement of firms and households. Finally, we get a new state of economic activities and compare the equilibrium with the original equilibrium without the TTFMs.[3]

The following macro settings are maintained:

- There is no immigration between the region covered in the simulation and the rest of the world.
- The national population of each country is assumed to increase at the rate forecasted by the United Nations Population Division until 2030.

In addition, we prohibit transit transport through Myanmar and through Bangladesh under the current situation. Therefore, in this case trade between China and India is mainly done by ocean routes passing through the Malacca Straits, or by air routes.

[3] GSM does not directly include the cost of reducing TTFM; in other words, the improvement of connectivity is exogenously and costlessly given in the setting of simulations.

3. Economic Impacts of Trade and Transport Measures in China and ASEAN

3.1. Improvement of AH3 between Shanghai and Kunming

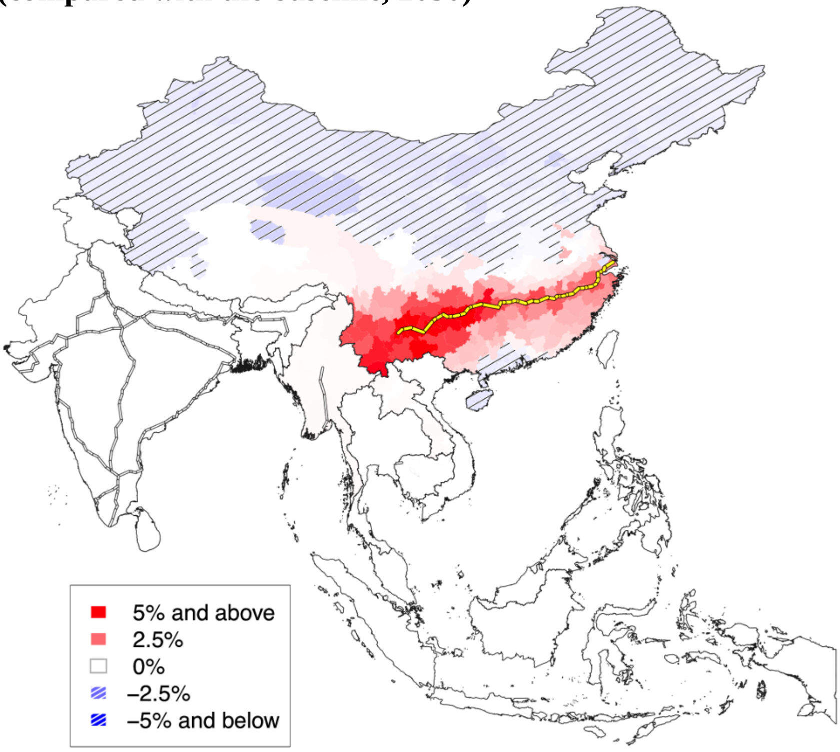
We first consider economic impacts of the development of a trunk road in China. We choose a road between Shanghai and Kunming. This section is designated as Asian Highway 3 (AH3) by UNESCAP as well as a part of 7918 Motorway Network in China[4]. We set scenario 1 as follows:

> **Scenario 1: Improvement of AH3 between Shanghai and Kunming**
>
> A new expressway between Shanghai and Kunming is constructed in 2015, and the speed of the expressway is enhanced to 60km/h.

Figure 4 presents economic impacts of the development in 2030. Compared with the baseline scenario, regions along the road will see positive impacts. In particular, regions of inland China such as Yunnan and Guizhou provinces will have larger economic gains than coastal regions. Guiyang, the capital of Guizhou province, will have a 5.44% gain, and Kunming will have a 5.21% gain (Table 1). Thanks to the higher economic growth in Yunnan and Guizhou provinces, the spatial Gini coefficient will be improved from 0.45309 to 0.4528, compared with the baseline scenario.

[4] The 7918 Motorway Networks consists of 7 radial expressways from Beijing, 9 vertical expressways connecting North and South, and 18 horizontal expressways connecting East and West.

Figure 4: Economic Impacts of Upgrading AH3 between Shanghai and Kunming (compared with the baseline, 2030)



Source: Authors.

Table 1: Top 20 Regions to Benefit from AH3 between Shanghai and Kunming (compared with the baseline, 2030)

Rank	Region	Country	Impacts
1	Qujing	China	5.58%
2	Anshun	China	5.52%
3	Guiyang	China	5.44%
4	Qiandongnan Miao and Dong	China	5.41%
5	Qianxinan (Buyei & Miao)	China	5.32%
6	Wenshan Zhuang Miao	China	5.29%
7	Kunming	China	5.21%
8	Qiannan Buyei and Miao	China	4.69%
9	Xishuangbanna Dai	China	4.30%
10	Huaihua	China	4.19%
11	Liupanshui	China	4.04%
12	Yuxi	China	4.02%
13	Simao	China	3.94%

Rank	Region	Country	Impact
14	Honghe Hani	China	3.32%
15	Shaoyang	China	3.27%
16	Hechi	China	3.24%
17	Dali Bai	China	3.22%
18	Bijie Prefecture	China	3.20%
19	Baise	China	3.19%
20	Baoshan	China	3.14%

Source: Authors.

Despite large positive impacts on regions along the road, China as a whole will have only a 0.32% positive impact. This is mainly because of the small share of Yunnan and Guizhou provinces in China's overall GDP, and negative impacts on other parts of China, which partially offset positive effects. Table 2 lists ten regions in China to be negatively affected by AH3 development. Many in the list are in the northern part of the country.

Table 2: Top 10 Regions in China to be Negatively Affected by AH3 between Shanghai and Kunming (compared with the baseline, 2030)

Rank	Region	Country	Impacts
1	Haixi(Mongol&Tibetan)	China	-0.64%
2	Beijing	China	-0.62%
3	Karamay	China	-0.58%
4	Ordos	China	-0.47%
5	Hohhot	China	-0.46%
6	Dongguan	China	-0.45%
7	Baotou	China	-0.44%
8	Yan'an	China	-0.43%
9	Suzhou, Anhui	China	-0.41%
10	Zhongshan	China	-0.40%

Source: Authors.

Impacts on other countries will be minimal. Laos and Myanmar will see positive impacts of 0.07% and 0.06%, respectively, while other countries will witness negligible impacts. Stimulating the economic activities in Yunnan province would potentially benefit exporters and importers in Laos and Myanmar, but high national border barriers will impede such spillover effects.

In summary, the development of AH3 in China will make the connectivity between core and periphery tighter and accelerate the growth of inland, resulting in narrowing a gap between costal area and inland to some extent. However, the positive effects are limited to regions along the highway. These regions will absorb resources from other regions, and thus negative impacts will be generated in the northern part of China. This suggests that policy makers may want to pay attention to keeping a good balance across regions and implement multiple projects at the same time in a coordinated manner. The case also suggests that international transmission of economic effects will be very small unless national border barriers will be lowered.

3.2. Kyaukpyu Deep Sea Port and Related Development

Second, we develop a scenario to estimate economic impacts of other countries' infrastructure developments on China. We select the Kyaukpyu deep sea port in Myanmar and related development.

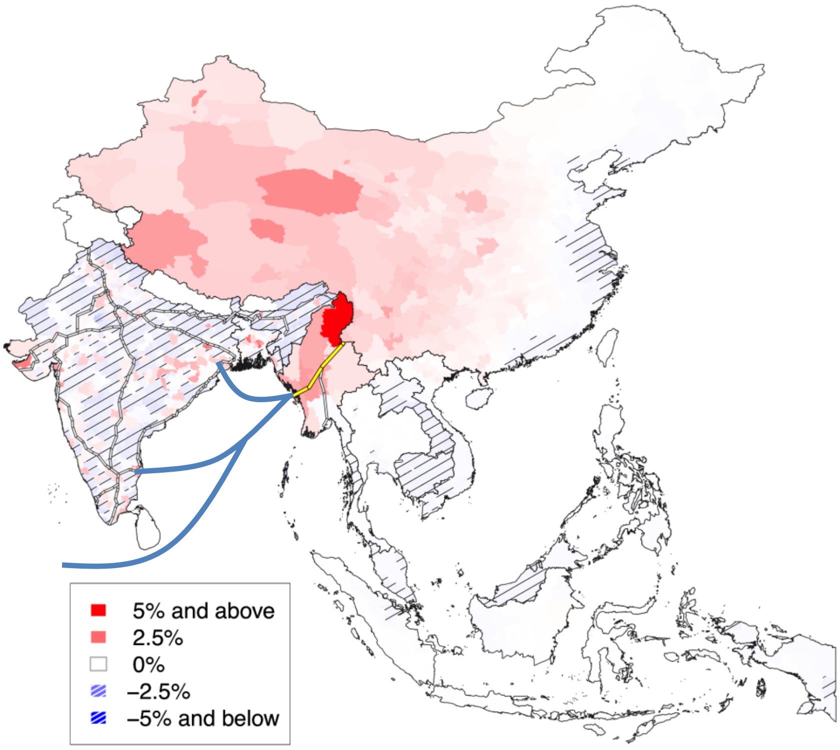
Kyaukpyu is strategically important for China that seeks a new gateway to the Andaman Sea. The development makes it possible to connect China and the Middle East/EU without passing through the Malacca strait. Myanmar Oil and Gas Enterprise (MOGE) and China National Petroleum Corp (CNPC) are now constructing a tanker port in Kyaukpyu and pipelines between Kayukpyu and Kunming via the Muse-Ruili border. Kyaukpyu also has a development plan for a large deep sea port and a special economic zone (SEZ). The development of the port and SEZ will be conducted by CITIC Group, China. There also exists a plan for high-speed railways between Kyaukpyu and Kunming. We set scenario 2 as follows:

Scenario 2: Kyaukpyu and related development

The highway between Muse and Kyaukpyu is improved in 2015, and the speed of the highway is enhanced to 60km/h. Border crossing facilitation between Muse and Ruili is introduced. Kyaukpyu is newly connected to Kolkata, Chennai, and Rotterdam via sea routes that are equivalent to other routes between internationally important ports. Transit transport between China and other countries through Myanmar is allowed only when companies use the improved highway and Kyaukpyu port.

Figure 5 and Table 3 present economic impacts of the development. Myanmar and most of inland China will benefit, which confirms the strategic importance of Kyaukpyu port, customs facilitation at the Muse-Ruili border, and transit trade through Myanmar. Kachin state, Myanmar will be the top beneficiary thanks to enhancing its connectivity with China. Haixi Mongol and the Tibetan Autonomous Prefecture and Karamay will see positive impacts of 1.89% and 1.66%, respectively.

Figure 5: Economic Impacts of Kyaukpyu and Related Development (compared with the baseline, 2030)



Source: Authors.

Table 3: Top 20 Regions Benefiting from Kyaukpyu and Related Development (compared with the baseline, 2030)

Rank	Region	Country	Impacts
1	Kachin	Myanmar	5.38%
2	Narayanganj	Bangladesh	2.79%
3	Sirajganj	Bangladesh	2.39%
4	Bokaro	India	2.21%
5	Jamnagar	India	2.07%
6	Gazipur	Bangladesh	2.00%
7	Haixi(Mongol&Tibetan)	China	1.89%
8	Karamay	China	1.66%
9	Thiruvallur	India	1.59%
10	Magway	Myanmar	1.58%
11	Valsad	India	1.58%
12	Ngari Prefecture	China	1.57%

Rank	Region	Country	Impact
13	Bongaigaon	India	1.48%
14	Narsingdi	Bangladesh	1.48%
15	Gautam Buddha Nagar	India	1.47%
16	Bharuch	India	1.45%
17	Panzhihua	China	1.44%
18	Angul	India	1.35%
19	Mandalay	Myanmar	1.35%
20	Sagaing	Myanmar	1.31%

Source: Authors.

Interestingly, economic impact on China is -0.006% even though most regions in inland China see positive impacts as shown in Figure 6. In fact, slight negative impacts on coastal areas will cancel out positive impacts on inland. Shanghai and Wuxi will suffer 0.27% and 0.30% losses of GRDP, respectively (Table 4). This implies that the development of Kyaukpyu and related development contribute to redressing disparities within China by stimulating economic activities in inland China with tighter international connectivity. Actually the spatial Gini coefficient of China improves from 0.4531 in the baseline scenario to 0.4527, which is a little larger effects than the AH3 scenario.

Table 4: Top 10 Regions in China to be Negatively Affected by Kyaukpyu and Related Development (compared with the baseline, 2030)

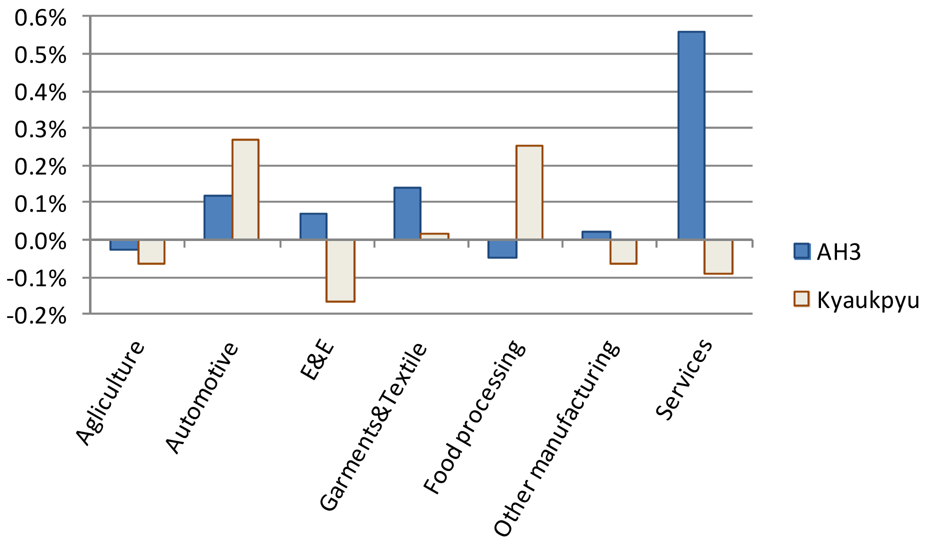
Rank	Region	Country	Impacts
1	Wuxi	China	-0.30%
2	Shanghai	China	-0.27%
3	Changzhou	China	-0.24%
4	Ma'anshan	China	-0.23%
5	Zhenjiang	China	-0.23%
6	Nanjing	China	-0.21%
7	Xiamen	China	-0.21%
8	Hangzhou	China	-0.20%
9	Yangzhou	China	-0.19%
10	Nantong	China	-0.18%

Source: Authors.

The Kyaukpyu development project is assessed as a complementary policy to "Western China Development." Inland China is land-locked and has a difficulty in getting access to foreign countries. The Kyaukpyu development enables these regions to lower high border barriers of Myanmar and assures the access to the world market through ocean transport. Broadly observed positive impacts in inland China are the results of this opening-up-to-the-West effect of the development project.

Finally, we compare economic impacts of two scenarios on China by industry (Figure 6). We see distinct differences. AH3 development will mainly foster services sector because the development includes large cluster surrounding Shanghai. On the other hand, the Kyaukpyu project will benefit automotive and food processing industries by better connectivity with the international market by inland China.

Figure 6: Economic impacts of AH3 and Kyaukpyu Development on China by Industry (compared with the baseline, 2030)



Source: Authors.

4. Conclusion

The balance between agglomeration and dispersion of economic activities and the implication of national border effects are focal points in designing and implementing development strategies of institutional and physical connectivity in pursuing both strong and inclusive economic growth in China and its neighboring countries. Our simulation model successfully visualizes a potential for further economic growth stimulated by infrastructure development and improved international connectivity.

Two distinctive scenarios provide us various insights on infrastructure development policies. In the case of AH3, we find that the positive economic impacts of physical road infrastructure developments that connect urban and rural tend to correct income disparity to some extent but be largely limited to the regions along the infrastructure. Regions far from the improved infrastructure are rather likely to suffer from negative impacts due to the leakage of economic activities, and thus policymakers may want to keep proper balance across regions. Moreover, economic impacts do not go beyond national border. In the case of the Kyaukpyu deep sea port project and related connectivity enhancement, the establishment of international logistics channels benefits broader regions in inland China and are effective in reducing development gaps. This is because the new gateway will contribute to pushing up the wage level in inland China and reduce excessive agglomeration in the coastal area. These policy simulations suggest that the combination and prioritization of the various projects matter when we pursue both stronger economic growth and narrowing development gaps.

Development literature of inclusive growth or pro-poor growth sometimes inclines too far toward "social policy" where direct measures of income redistribution are taken for granted. In China and East Asia, however, there is ample room for utilizing "economic policy" to pursue both strong economic growth and the narrowing of development gaps at the same time. Robust growth of productive sectors and the proliferation of the 2nd unbundling provide huge potential for presenting a new development strategy, and connectivity is the key for utilizing such mechanism. Analytical tools for spatial designing such as GSM should be further developed to fill huge demand for serious policy research.

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