ECONOMIC IMPACT ANALYSIS OF IMPROVED CONNECTIVITY IN NEPAL

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NO. 75

November 2020

ADB SOUTH ASIA
WORKING PAPER SERIES

ADB South Asia Working Paper Series

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www.adb.org

ISSN 2313-5867 (print), 2313-5875 (electronic)
Publication Stock No. WPS200312-2
DOI: <http://dx.doi.org/10.22617/WPS200312-2>

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ABBREVIATIONS

ADB	Asian Development Bank
GDP	gross domestic product
GRDP	gross regional domestic product
ICD	inland container depot
IDE-GSM	geographical simulation model developed by the Institute Developing Economics
SASEC	South Asia Subregional Economic Cooperation

ABSTRACT

This study has estimated the economic impact of ongoing and future infrastructure development projects in Nepal by using the geographical simulation model developed by the Institute of Developing Economies (IDE-GSM). The IDE-GSM is a computational general equilibrium model based on spatial economics. The simulation analysis reveals that ongoing infrastructure development projects in Nepal benefit the country's economy, and that the planned connectivity improvement with India will have positive impact, with anticipated major shift in mode of transport for trade.

I. INTRODUCTION

1. As a landlocked country, Nepal is hampered by its high domestic and international trade costs. Relatively poor infrastructure makes it difficult to boost the country's export competitiveness. The Government of Nepal has been promoting road improvement and facilitation of customs procedures. ADB has been supporting the government in strengthening Nepal's domestic connectivity and promoting international connectivity under the South Asia Subregional Economic Cooperation (SASEC) framework. Improving connectivity infrastructure is one of the priorities of the Government of Nepal.

2. In road sector development, the priority is improving the 1,027-kilometer (km) East–West highway, which is the country's main artery, with the heaviest traffic into the Terai region along the southern border of Nepal with India. Currently, the sections between Narayanganj and Butwal (about 160 km) in the middle of Nepal and between Kamala and Kanchanpur (about 85 km) in the eastern part of Nepal are being rehabilitated and upgraded to four lanes. These projects are supported by ADB's SASEC Roads Improvement Project committed in 2016 and ADB's SASEC Highway Improvement Project committed in 2018.

3. In the railway sector, the Janakpur railway connects Jayanagar in India with Kurtha in Nepal for 35 km. The narrow gauge has been replaced by a broad gauge in 2019. India has supported on a grant basis the construction of that broad gauge, hence it has been connected to the Indian railway network. The Government of Nepal is in the process of procuring a passenger train from India. No freight train is planned as of now. Another railway line lies between Raxaul in India and Sirsiya Inland Container Depot (ICD) near Birgunj, a project that also has been supported by India. The 6-kilometer railway line is used for freight transport.

4. In the air transport, the Gautam Buddha airport, located close to the Buddha's birthplace Lumbini, is being upgraded to the second international airport in Nepal. This airport upgrading is supported by ADB's South Asia Tourism Infrastructure Development Project committed in 2009, while the first international airport in Kathmandu is being strengthened under ADB's Tribhuvan International Airport Capacity Enhancement Investment Program committed in 2016.

5. Currently, around half of the cargo coming to Nepal enters through Birgunj, either through the old border point, the Integrated Customs Points (ICP), or the ICD. The ICP and the old border point focus on trucks, while the ICD is used only for railway cargo. ICD operations started in 2005 and originally handled transit cargo only, but it now handles cargo from India as well. The ICD receives three trains every two days. Each train carries 45 containers (equivalent to 40 feet, though most are 20-foot containers). There are three more ICPs planned in Nepal in addition to that of Birgunj. The ICP in Biratnagar has just started operation, and that of Nepalgunj is under construction, and another construction will start in Bhairahawa. The umbrella grant agreement with India identified three more border points for railways in addition to Birgunj and Janakpur—Biratnagar, Bhairahawa, and Nepalgunj.

6. Nepal has made a global commitment to undertake customs reforms by acceding to the World Trade Organization's Trade Facilitation Agreement (TFA). It aims to simplify, modernize, and harmonize export and import processes primarily through reforms in customs clearance procedures. The New Customs Act incorporating the TFA commitments are drafted and submitted to the Cabinet in 2019 for proposal to the Parliament. Its implementation is expected to shorten time for customs clearance at the borders.

7. The government announced in 2018 several new plans to strengthen connectivity. In April 2018, during the visit of the Prime Minister of Nepal to India, both sides issued a joint statement on establishing new connectivity via inland waterways. In August, the Government of Nepal and the Government of India signed a memorandum of understanding to conduct a preliminary engineering-cum-traffic survey on a new railway from Raxaul, India to Kathmandu, Nepal.

8. This study estimates the impact of above infrastructure projects and the trade facilitation reform on Nepal's economy with the geographical simulation model developed by the Institute of Developing Economies (IDE-GSM) (Kumagai et al. 2013). The IDE-GSM as a simulation tool has three advantages: subnational economic data with sector breakdown, logistics networks, and agglomeration.

9. First, economic data used for IDE-GSM is constructed at subnational regions such as districts, which are smaller than provinces, states, and prefectures. The model also includes eight industrial classifications. With such detailed data, the economic impact of infrastructure projects can be obtained by industry for each subnational region.

10. Second, IDE-GSM incorporates all modes of logistics networks such as roads, railways, ships, and air. As the connectivity among regions are multi-layered, infrastructure projects can alter the mode of transport for trade. Further, the economic impact of infrastructure development can be transmitted through the logistics network. Thus, the impact can be found not only in close proximity to the projects but also in far regions, and even in other countries.

11. Third, as IDE-GSM incorporates the mechanism of agglomeration, it can estimate the changes in the industry and population distribution brought about by infrastructure projects and the trade facilitation thus creates winner and losers.¹ The regions where infrastructure projects are implemented usually become relatively advantageous compared with other regions. The regions with projects will attract industries and households from the other regions thus giving the others negative economic impact. Even within the a region, if one industry becomes more advantageous than the others because of the infrastructure projects, it attracts labor from other industries and giving them damages. Thus, IDE-GSM can simulate the impact in multiple dimension.² By simulating different scenarios, better combinations of projects can be explored.

¹ Similar to urbanization and industrial clustering, spatial distributions of economic activities have some tendency of agglomeration. See for example, Fujita et al. (1999).

² Novelty of IDE-GSM lies in this capability of multidimensional impact evaluation. This is in line with the recent publication from the World Bank, Melecky et al. (2018), encouraging impact evaluation in terms of wider economic benefits.

II. LITERATURE REVIEW

12. Studies suggest that there is a positive correlation between improved quality of infrastructure and economic growth, and that better connectivity enables countries join the global value chain. Improved connectivity lowers transaction costs for producers and reduces congestion thus generating more outputs and eventually raising productivity and profitability potential. Such connectivity is crucial for regional cooperation and trade and encourages countries to fill in the fragmented production process (ADB 2006, ADB 2009).

13. The economic impact of improved connectivity works through agglomeration effect and rises in trade and migration. Over the long term, connectivity alters the economic structure—generating income, consumption demand, new jobs, and greater equity—which are viewed as wider economic benefits (ADB, UKAID, JICA, and WB 2018). Enhanced connectivity allows economic entities to acquire new ideas and knowledge from other economic centers, thus raising productivity and generating competitive advantage (Rodriguez-Pose and Fitjar 2013). However, positive outcome is a function of complementary policies along with improved facility. For example, the study of Melecky et al. (2018) reveals that better connectivity results in lower poverty levels only if the adjoining district has existing industry base; or wages will go up with better infrastructure if education levels are higher within the facility's vicinity.

14. Kumagai and Isono (2011) used the IDE-GSM model to assess the economic impact of better ASEAN–India connectivity. Key findings are as follows: Firms can buy and sell at a better price due to lower transport cost, contributing to better economic growth. Physical connectivity should be supplemented by better institutional policies, including streamlining of procedures and using technology. Cross-border movement of people is also crucial. Improved connectivity will boost regional production networks, encouraging new economic activities and job creation. Enhanced connectivity reduces trade cost, raising a country's comparative advantage and trade flows. It also leads to better market access, lowers poverty levels, and raises human welfare and quality of life.

15. Warr et al. (2009) studied the economic impact of improved infrastructure facilities. They created a general equilibrium model based on an input–output structure. The study divided a single economy in two regions that are trading with each other and are also trading with the rest of the world. The findings were listed over two time periods: short- and long-term. Short-term results showed a moderate rise in two-way trade between regions. The benefits are large over the long run as new investments come in and the labor force migrates to another region for better jobs and higher wages.

16. Isono and Kumagai (2013), using IDE-GSM, estimated the impact of reforms on Yangon's Dawei port and on domestic connectivity enhancement of Myanmar and regional economies. The findings are as follows: The reforms will contribute to Myanmar's economic growth and inclusive development, avoiding agglomeration and congestion in specific areas. In particular, the Dawei port will promote inclusive growth in Myanmar and neighboring countries, thus narrowing the development divide.

17. Another study by Kumagai et al. (2018) concludes that road projects between Bhutan and India has the potential to improve Bhutan's trade prospects, thus bringing positive impact on Bhutan's economy. Bhutan may benefit less compared to India's northeastern states due to the former's difficult mountainous terrain and high nontariff barriers between the countries. On the other hand, De et al. (2013) assessed the impact of trade facilitation and related policies on poverty reduction in South Asian Association for Regional Cooperation countries. They conclude that better trade infrastructure leads to job creation and greater income opportunities, which in turn augments local production, and in the process reduces poverty. Lastly, Kumagai et al. (2017) studied the impact of a railway network and improved customs facility between the Kyrgyz Republic and the People's Republic of China (PRC). They conclude that southern Kyrgyz Republic has gained some development benefits while the northern region has experienced a negative impact.

III. MODEL, DATA, AND SIMULATION METHODOLOGY

A. Model

18. The IDE-GSM is a multiregional and multisectoral model based on New Economic Geography which can capture the concentration of firms (clustering or agglomeration) and households (urbanization) (Krugman 1991; Fujita et al. 1999). The IDE-GSM evaluates the regional economic impact of improved connectivity in physical infrastructure such as new and upgraded roads, and in nonphysical infrastructure such as trade facilitations, harmonization of custom procedures, and reductions in administrative procedures for trades. The IDE-GSM simulates regional dynamics in population and economic growth with and without specific infrastructure projects, and estimates the projects' economic impact. Therefore, the IDE-GSM can provide information to assess and prioritize various infrastructure development projects. It serves as an objective evaluation tool for policy recommendation in infrastructure development.

19. The IDE-GSM comprises agriculture, mining, five manufacturing sectors, and service sector. All products of the sectors are tradable. The transport cost is assumed as an iceberg type—that is, if one unit of a good is sent from one area to another, a good with less than one unit arrives. Depending on the loss from the transport, the supplier sets a higher price for the good. The increase in price compared to the price of the producer's place is considered as the transport cost. Transport cost within the same area are considered negligible (Kumagai et al. 2017). Factor inputs are arable land and labor force. Workers are mobile within countries and between sectors, but international migration does not happen.

20. Simulation with the IDE-GSM determines the following regional variables: nominal wage rates in the eight sectors, land rent, regional income, regional expenditure on manufactured goods, price index of three sectors, average real wage rates in the sectors, population share of a location in a country, and population shares of the sectors within each location (Isono et al. 2016). The basic structure of the model is shown in Figure 1.

B. Data

Geo-economic data set

21. The geo-economic dataset covers 186 countries and economies and 3,137 subnational regions, and include data for the year 2010. The gross regional domestic products (GRDP) for the agriculture sector, mining sector, five manufacturing sectors, and service sector is derived primarily from official statistics. The five manufacturing sectors are food processing, garments and textiles, electronics and electric appliances, automotive, and other manufacturing industries (Kumagai et al. 2017). National and regional gross domestic product (GDP) data from industrial survey or census are used to divide the GRDP into five sectors. The geo-economic dataset for countries that do not have subnational economic data are constructed with the night-time satellite imagery and land use data (Keola and Kumagai 2016). The interpolation method of GDP in the mining sector was further improved by the number of mines by each mineral resource and the mineral export data for each country.

Transport network data

22. The number of routes included in the transport network data is 16,519 (land: 11,079; sea and inland waterways: 1,360; air: 2,518; and railways: 1,562). The route data consists of information on start city, end city, distance between cities, and the speed of the vehicle running on the route, among others. The land routes between cities are mainly based on the Asian Highway database of the United Nations Economic and Social Commission for Asia and the Pacific (UNESCAP), supplemented by the routes shown on various maps. Actual road distance between cities is used if the data is available. If not, distance between cities in a straight line is applied. Data on the air and sea routes was compiled mainly from Nihon Kaiun Shukaijo (1983) and the data set assembled by the team of The Logistics Institute - Asia Pacific (TLIAP). The railway data was adopted from various sources, such as maps and official websites of relevant railway companies (Kumagai et al. 2017).

Data for Nepal

23. The geo-economic dataset for Nepal was updated to a dataset for 77 districts under seven provinces from the original dataset for five provinces before the federal system was introduced. Official statistics taken from the Statistical Yearbook of Nepal was used to compile the data at the district level. GRDP data by industry was compiled using the population share by industry and district with “usually economically” active population 10 years of age and over, by industry and sex, as of 2011.

24. Among the transport network data, road connectivity information was extracted from various road network data provided by the Department of Roads. For other modes of transport, such as air transport, railways, and inland waterways, the network data was constructed from various information obtained from the government. Note that domestic airlines in Nepal is not included in the dataset. The dataset includes international air service between Tribhuvan International Airport in Kathmandu and Bahrain; Bangladesh; Bhutan; Hong Kong, China; India; the Republic of Korea, Malaysia; Oman; Pakistan; the PRC; Qatar; Singapore; Thailand; and United Arab Emirates. The baseline scenario includes the railway service between Raxaul (India) and Birganj (Nepal) and between Jayanagar (India) and Janakpur (Nepal).

C. Simulation Methodology

25. The economic impact of improved connectivity is evaluated by comparing simulation results under different scenarios (Figure 2). One is a baseline scenario which assumes there is no infrastructure development that has taken place. The other one is a development or an alternative scenario where a specific connectivity development has been implemented. Simulation in each scenario is undertaken for 20 years from the base year of 2010. Economic impact is obtained by comparing GRDPs between two scenarios in 2030. If the GRDP of a region under the development/alternative scenario is higher (lower) than that of the baseline scenario, the surplus (deficit) amount is regarded as the positive (negative) economic impact of a specific connectivity development. A notable merit of calculating the economic impact by taking the difference between scenarios is the stability of results. The economic indices forecasted by a simulation depend on various parameters while the differences of the economic indices are quite stable regardless of the changes in parameters (Isono et al. 2016).

26. Simulation under the baseline scenario assumes that the national population of each country increases at the rate forecast by the UN Population Division until the year 2030. The labor force increase is considered as the driver of economic growth. The IDE-GSM allocates the labor force among sectors and regions in a country, and determines GRDP in each region. Further, it is assumed that tariff and non-tariff barriers are changing based on free trade agreements and economic partnership agreements currently in effect.

D. Strength and Challenges of the Simulation

27. As already pointed out, the IDE-GSM can provide simulation results at subnational regions, taking into account industry agglomeration; urbanization; and all transportation modes of roads, railways, sea and inland water ways, and air. The model is however subject to the following challenges which should be noted.

28. First, capital is not included as a factor input. Capital stock data by region is limited which constrains the model from including capital accumulation as a mechanism of economic growth. However, since the simulation covers a long period of more than 10 years to accommodate long adjustment time for labor mobility, the lack of capital accumulation handicaps the model to consider an important aspect of economic growth.

29. Second, the Cobb–Douglas type of combination of labor and synthetic manufactured goods may also call attention. Factor and intermediate inputs usually do not substitute each other but can be combined with Leontief function.

30. Third, the simulation is not path dependent. In case of simulation with multiple scenarios, the model does not distinguish sequence of the scenarios. Simulation of project A followed by project B generates the same results even though the sequence of the projects being implemented are reversed. In reality, however, the sequence of projects should matter. First, a project alters industry agglomeration and competitiveness. Regions that are developed earlier than others have advantage in later development. However, this simulation in the model cannot have the same parameters. The lack of capital accumulation in the model could generate a reversibility of agglomeration.

31. Finally, the model does not allow cross-border movement of labor force. This assumption spares the study from the data constraints of immigration. Excluding the data on migration, however, may affect the simulation results of a country, such as Nepal, that has a large number of overseas workers. Assumption of free service trade among countries is also not realistic since restrictions for service trade are usually much higher than those for trade of goods.

IV. SCENARIOS AND SIMULATION RESULTS

A. Scenarios

32. Two scenarios are simulated to analyze the economic impact of infrastructure development in Nepal. Scenario 1 is about ongoing projects in Nepal, and scenario 2 is on planned connectivity with India. Scenario 1 involves ongoing investment projects which are likely to be completed within a few years.

Scenario 1 Assumptions

By 2020

- Sections in East–West Highway between Kamala and Kanchanpur and between Narayangarh and Butwal are improved so that truck speed is increased from 30.0 kilometers/hour (km/h) to 38.5 km/h.
- Tribhuvan International Airport has better handling, so that waiting time for transit is reduced by 25% for both air cargo and passengers.
- Gautam Buddha International Airport starts international service with Dubai, Doha, Bangkok, Kuala Lumpur, and Delhi.
- Waiting time for transit at Birganj is reduced by 30%.
- Non-tariff barriers are lowered by 1% reflecting a reduced number of necessary documents for trade and a simplified border procedure

By 2021

- Janakpur railway is extended up to Bardibas along the East–West highway and has started operation. It is assumed that freight service has started.

By 2022

- Construction of a new 76-km highway between Kathmandu and Nijgadh is completed and has started operation. The new highway will shorten the road distance from 136 km to 76 km. Construction is currently undertaken by the Nepal army.

33. Scenario 2 estimates the economic impact of projects agreed between the Governments of Nepal and India. The projects include railway expansion from Birganj to Kathmandu and inland waterways development from Kolkata port in India to Nepal. Currently, there is a railway connection from Raxaul in India to Inland Container Depot (ICD) near Birganj in Nepal just across the border. The Governments of Nepal and India signed a memorandum of understanding for conducting a preliminary engineering-cum-traffic survey of the new railway line from Birganj to the proposed ICD in Chovar, Kathmandu on the sidelines of the Fourth Bay of Bengal Initiative for Multi-sectoral Technical and Economic Cooperation (BIMSTEC) Summit held in August 2018. Once the survey work is completed, Nepal and India will finalize the implementation and funding modality of this project. Development of inland water connection between India and Nepal was agreed between the Governments during the state visit of Nepal's Prime Minister to India on 6–8 April 2018. Nepal can possibly transit import and export goods from third countries via Kolkata, Haldia and Garden Reach using the inland waterways.

Scenario 2 Assumptions

By 2025

- The new inland waterway is built from Kolkata to Rampuramalhaniya and from Kolkata to Tribeni, both via Krusela in India. Transit transport through India requires transshipments twice at Kolkata port and Krusela port.
- The railway is extended from Birgunj to Kathmandu.

B. Simulation Results

Economic Impact by Country

34. Table 1 summarizes the economic impact of infrastructure development in selected countries. Scenario 1 has significant positive economic impact on Nepal corresponding to the assumptions of major projects to improve connectivity within Nepal as well as trade facilitation between India and Nepal. The economic benefit in terms of GDP in the year 2030 reaches \$355 million or 0.9% more than that of the baseline scenario. Among trade counterparts in developed countries, Japan and the United States (US) will have negative economic impact and the European Union will have a positive one, though these are negligible compared to their size of economies. Other countries to benefit include the PRC (\$12 million), the Republic of Korea (\$11 million), and Singapore (\$8 million).

35. Scenario 2 also has positive economic impact on Nepal, though the magnitude of \$1.2 million or 0.003% of the baseline is much less than that of scenario 1. This is partly because projects included in the assumptions are much less. It does not have economic impact in the European Union, Japan, the US, and others. As explained later, the scenario has major impact on mode of trade rather than on the GDP.

Table 1: Economic Impact by Country in 2030

(\$ million, 2010 price, % change)

	Scenario 1	Scenario 2
Nepal	355	1.2
	0.9%	0.0%
United States	-63	0.4
	-0.0%	0.0%
European Union	38	-0.2
	0.0%	-0.0%
Japan	-1	-0.2
	-0.0%	-0.0%

Source: IDE-GSM simulation result.

Economic Impact on Nepal by Region and by Sector

36. Under scenario 1, the regional allocation of economic impact within Nepal is concentrated in Kathmandu and along the southern border with India (Figure 3). This is a consequence of assumed connectivity improvement such as that of the airport in Kathmandu and the East-West highway. The new international airport in Lumbini also raises the regional GDP of the area. Trade facilitation also benefits the border area since most of the trade is with India. Kathmandu and the nearby districts (Lalitpur and Bhaktapur) all together benefit from economic impact of \$140 million. Beneficiary districts along the border includes Morang, Jhapa, Sunsari, and Ilam (Province 1); Sarlahi, Rautahat, Parsa, Bara, and Saptari (Province 2); and Rupandehi (Province 5). Regions around Pokhara and east of Kathmandu, on the other hand, did not experience positive economic impact compared to the baseline scenario. This result comes from the assumption that focuses on ongoing projects which has not captured the planned (but not yet started) projects such as ADB's SASEC Mugling-Pokhara Highway Improvement Phase 1 Project. Implementation of these projects will improve connectivity and bring economic benefits to these regions.

Figure 3: Economic Impact of Scenario 1 in 2030

(\$ million, 2010 price)

Source: IDE-GSM simulation result.

37. The positive economic impact in Kathmandu and the southern border regions is mostly driven by the service sector (Table 2). Other manufacturing and agriculture sectors have gained minimal benefit, while the food processing sector suffered from negative impact.

Table 2: Economic Impact on Nepal by Sector, 2030
(\$ million, 2010 price, % share of total)

	Scenario 1		Scenario 2	
Agriculture	5	1%	0.1	7%
Mining	0	0%	0.0	2%
Food processing	-11	-3%	0.4	30%
Textile	-1	0%	0.0	1%
Other manufacturing	8	2%	1.4	119%
Services	354	100%	-0.7	-60%
Total	355	100%	1.2	100%

Note: Since electronics, electric appliances, and automotive sectors are very small in Nepal, these are combined with other manufacturing sector.

Source: IDE-GSM simulation result.

38. The economic impact under scenario 2 is concentrated in Kathmandu and in the east of Nepal. These results correspond to the assumption that connectivity between Kathmandu and India has improved due to direct railway service from Birgunj (the major border point with India) and inland waterway along the Koshi river (Figure 4). Morang district has gained the largest economic benefit, followed by Sunsari, Jhapa, Saptari, Kathmandu, Ilam, Dhankuta, Bhojpur, Khotang, Sankhuwasabha, and Panchthar districts (all except Kathmandu belong to Province 1). Agriculture, food processing, and other manufacturing sectors have the biggest positive impact in eastern Nepal while Kathmandu benefitted from the other manufacturing sector. Service sector however affected from negative economic impact in all of these districts.

Figure 4: Economic Impact of Inland Waterway and Railway from India, 2030
(\$ million, 2010 price)

Source: IDE-GSM simulation result.

Trade Value by Mode of Transport

39. Trade value by transport mode under the baseline scenario reveals that trade by railway (through Birgunj) expands faster and exceeds the trade by road (Table 3).³ It is estimated that about half (48%) of all trade value is transported by railways in 2030.

40. Scenario 1 adds another railway connection to Bardiba through Janakpur. The new railway connection however does not affect the existing railway connection through Birgunj. The trade value through the Janakpur railways (\$1,376 million) remains much less than the value of trade by rail at Birgunj (\$71,433 million). Compared to the baseline scenario, the total trade value under scenario 1 increases by 0.9%.

41. Scenario 2 has substantial impact on the mix of trade mode despite its minimal economic benefit. With the combined assumptions under scenarios 1 and 2, the new inland waterway will service about a quarter (26%) of trade value of Nepal, most of which is taken over from railways. Low transport cost of the inland waterway (\$0.24 per kilometer compared to \$1/km for road and \$0.5/km for railway, see Appendix 1) attracts cargo despite the transshipment requirement at Krusela port. The share of railway transport drops to 30% mainly from Birgunj, while that of Janakpur railway is limited. This is because railway through Birgunj and inland waterway compete for transit cargo from third countries through India. Among the two ports for inland waterway, ports at Rampuramalhaniya and Tribeni are evenly utilized.

Table 3: Trade Value of Nepal by Mode of Transport, 2030

(\$ million, 2010 price, % share of total)

		Baseline		Scenario 1		Scenario 1+2	
Road		60,458	41%	59,106	39%	47,753	32%
Rail		70,592	48%	72,810	49%	44,775	30%
	Birgunj	70,592	48%	71,433	48%	43,416	29%
	Janakpur	–	–	1,376	1%	1,359	1%
Inland Waterway		–	–	–		39,604	26%
	Rampuramalhaniya	–	–	–		20,849	14%
	Tribeni	–	–	–		18,756	12%
Air		17,499	12%	17,941	12%	17,935	12%
Total		148,550	100%	149,857	100%	150,067	100%

Source: IDE-GSM simulation result.

³ Any part of railway via Janakpur is assumed not operational under the baseline scenario.

V. CONCLUSION

42. This paper estimated the economic impact of ongoing projects in Nepal and the proposed development of alternate connectivity with India. To undertake the simulation, database for Nepal was updated to include geo-economic dataset for 77 districts.

43. The simulation results have confirmed the substantial economic benefits gained from ongoing projects. The economic benefits are concentrated in Kathmandu and in districts along the southern border with India since projects to improve connectivity under the scenario are limited to ongoing projects. It is however expected that future projects will provide benefit to other regions and rebalance the regional economic impact.

44. Economic benefit is also projected from the proposed railway and inland water connection with India. Following the location of these projects, the impact is concentrated in Kathmandu and east Nepal. It is expected that these projects will result to a major shift in mode of trade. While railway will gain about half of the trade with India before the inland waterway, the share of railway will drop to a third once the inland waterway has started operation.

45. While this study presented the economic impact in 2030, the same is available for each of the simulated year. As a way forward, the measured economic benefits may be utilized as inputs to the cost-benefit analysis of an infrastructure project. It is possible to project the economic impact in terms of their present value and evaluate them in relation to or against project cost. This can serve as a background information for economic viability assessment of projects.

APPENDIX: DETAILED METHODOLOGY USED IN THE GEOGRAPHICAL SIMULATION MODEL

A. The Model

1. The theoretical foundation of Institute of Developing Economies (IDE-GSM) follows Puga and Venables (1996), which provides the basis of multisector and country general equilibrium of New Economic Geography (NEG). The model in this paper is a modified version of Kumagai and Isono (2011).⁴ Therefore, the explanation below pertains only to equations in equilibrium. It should however be noted that IDE-GSM differs from that in Puga and Venables (1996) in terms of specifications of the agriculture sector. IDE-GSM explicitly incorporates land size in its production and keeps its technology as constant returns to scale.⁵

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

3. Regional incomes in the NEG model correspond to regional gross domestic products (GDPs) in the study's simulations (Isono et al. 2016). Assuming that revenues from land at location r belong to households at location r , GDP at location r is expressed as follows:

$$Y(r) = \sum_{l \in \{\text{the list of all industries}\}} w_l(r)L_l(r) + r_A(r)\delta F(r) + r_m(r)(1-\delta)F(r) + TA(r)$$

where $r_A(r)$ is the land rent in the agricultural sector, δ is the ratio of the land used for agriculture, $F(r)$ is the land size, $r_m(r)$ is the land rent in the mining sector, $TA(r)$ is the revenue from the tariff, $W_l(r)$ is the wage rate of industry, l and $L_l(r)$ is labor input of industry l at location r , respectively.

4. The price index of agricultural goods, manufactured goods, and services products at location r is expressed as follows:

$$G_A(r) = \left[\sum_{s=1}^R A_A(r)^{\sigma_A-1} p_A(r)^{-(\sigma_A-1)} T_{sr}^{A-(\sigma_A-1)} \right]^{\frac{1}{-(\sigma_A-1)}},$$

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

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

⁴ For other simulation analysis based on New Economic Geography, see Teixeira (2006) and Robert et al. (2012).

⁵ For detailed derivations, see Puga and Venables (1996) and Fujita et al. (1999).

where

$$p_A(r) = \left[\mu_A \sum_{s=1}^R Y(s) G_A(s)^{\sigma_A-1} T_{sr}^{A-(\sigma_A-1)} / f_A(r) \right]^{\frac{1}{(\sigma_A-1)}},$$

β is the input share of labor in producing manufactured goods; μ_A is the consumption share of agricultural products; A_A , A_M , and A_S are productivity parameter⁶ for location r ; T_{sr}^A , T_{sr}^M and T_{sr}^S stand for the iceberg transport costs from location r to location s ; and σ_A , σ_M , and σ_S are the elasticity of substitution between any two differentiated manufactured goods for agricultural, manufactured, and services goods, respectively. Nominal wages in the agriculture, manufacturing, and services sectors at location r are expressed as follows:

$$w_A(r) = \alpha A_A(r) \left(\frac{F(r)}{L_A(r)} \right)^{1-\alpha} p_A(r),$$

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

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

5. 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:

$$\dot{\lambda}_l(r) = \gamma_l \left(\frac{\omega_l(r)}{\bar{\omega}(r)} - 1 \right) \lambda_l(r), l \in \{A, M, S\},$$

where $\dot{\lambda}_l(r)$ is the change in labor (population) share for a sector within a location, γ_l is the parameter used to determine the speed of switching jobs within a location, $\omega_l(r)$ is the real wage rate of any sector at location r , $\bar{\omega}(r)$ is the average real wage rate at location r , and $\lambda_l(r)$ is the labor share for a sector in the location. The population share for a sector within a country is expressed as follows:

$$\lambda_l(r) = \frac{L_l(r)}{L_A(r) + L_M(r) + L_S(r)}.$$

where $L_A(r)$ is labor input of the agriculture sector at location r .

⁶ We omit capital and capital accumulation and substitute them by productivity parameter A and its increment by the calibration.

6. The dynamics of labor migration between regions is expressed as follows:

$$\dot{\lambda}_L(r) = \gamma_L \left(\frac{\omega(r)}{\bar{\omega}_C} - 1 \right) \lambda_L(r)$$

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

$$\omega(r) = \frac{Y(r) / (L_A(r) + L_M(r) + L_S(r))}{G_A(r)^{\mu_A} G_M(r)^{\mu_M} G_S(r)^{\mu_S}}$$

where μ_A , μ_M and μ_S shows the consumption share of agriculture, manufacturing, and services, respectively.

B. Parameters

Transport cost

7. Transport cost comprises physical transport costs, time costs, and tariff and nontariff barriers. Physical transport costs are a function of distance travelled, travel speed per hour, physical travel cost per kilometer, and holding cost for domestic/international transshipment at border crossings, stations, ports, or airports (Table A1). Time costs depend on travel distance, travel speed per hour, time cost per hour, holding time for domestic/international transshipment at border crossings, stations, ports, or airports (Table A2). Both parameters are derived from ASEAN Logistics Network Map 2008 (JETRO 2008) and by estimating the model of the firm-level transport mode choice using data from Establishment Survey on Innovation and Production Network for 2008 and 2009 which includes manufacturers in Indonesia, the Philippines, Thailand, and Viet Nam.

Table A1: Unit Cost, Speed, and Time in the Transport Cost Function

	Truck	Sea/waterway	Air	Rail	Unit
<i>Cost per distance</i>	1	0.24	45.2	0.5	\$/km
<i>Speed</i>	38.5	14.7	800	19.1	km/hour
<i>Transit time (domestic)</i>	0	11.671	9.01	2.733	hours
<i>Transit time (international)</i>	13.224	14.972	12.813	13.224	hours
<i>Transit cost (domestic)</i>	0	190	690	0	\$
<i>Transit cost (international)</i>	500	504.2	1308.1	500	\$

Notes: Costs are for a 20-foot container. The parameter transit cost (domestic) is assumed to be half of the sum of border costs and transshipment costs in international transport from Bangkok to Hanoi. The parameter transit time (domestic) and transit cost (domestic) for sea and air include one-time loading at the origin and one-time unloading at the destination.

Source: Authors' estimation and ASEAN Logistics Network Map 2008.

Table A2: Time Costs per One Hour, by Industry
(\$ per hour)

Food	Textile	Machineries	Automobile	Others
15.7	17.2	1803.3	16.9	16.5

Source: Authors' calculation.

8. Based on these parameters, the sum of physical transport and time costs for possible routes between all combination of two regions are calculated. The optimal route and transport mode for each pair of region for each goods/services are determined by the Floyd–Warshall algorithm (Cormen et al. 2001).

9. The average speed of land traffic is basically set at 38.5 kilometers per hour (km/h). The speed is adjusted to half (19.25 km/h) on roads in mountainous areas and to 60 km/h on selected roads—namely, roads in Thailand outside traffic-congested metropolitan Bangkok, the road from the border of Thailand to Singapore through the west coast of Malaysia, and roads No. 9 and No. 13 from Vientiane to Pakse in the Lao People's Democratic Republic. The average speed for sea traffic is set at 14.7 km/h between international class ports and at half of that on other routes. Average air traffic speed is set at 800 km/h between primary airports of each country and at 400 km/h on other routes. Average railway traffic speed is set at 19.1 km/h (Isono et al. 2016).

10. The tariff and nontariff barriers for each industry in each country is estimated for the year 2007 by log odds ratio approach which is initiated by Head and Mayer (2000). The data sources are as follows: consumption data is from the GTAP 8 Data Base, GDP, and GDP per capita from the World Development Indicators, and the geographical distance and three dummy variables on preferences are from CEPII database. The estimation provides industry-level fixed effects for 69 countries. Nontariff barriers are obtained by subtracting tariff rates from the tariff and nontariff barriers. The tariff rates are extracted from the World Integrated Trade Solution, particularly Trade Analysis and Information System (TRAINS) raw data.

Input share of labor in producing manufactured goods

11. Labor input share ($1-\beta$) of each industry is assumed to be uniform among the regions and throughout the time period in the model. The share of Thailand as a country in the middle-stage of economic development is used, which is taken from the Asian International Input–Output Table 2005 by IDE and Zai-Asia Oceania Nikkei Kigyo Jitta Chosa 2013 by JETRO. The obtained parameter of β is 0.39 for agriculture sector, 0.39 for food processing sector, 0.36 for garments and textiles sector, 0.44 for electronics and electric appliances sector, 0.43 for automotive sector, 0.41 for other manufacturing sector, and 0.0 for service sector.

Consumption share

12. The consumption shares of goods and services (μ) is assumed to be the same in all regions in the model because of lack of sufficiently reliable consumption data. The consumption shares are set to be identical to the industry's production share in GDP for the entire world in 2010. The parameter values used in IDE-GSM are as follows: 0.040 for agriculture sector, 0.033 for food processing sector, 0.018 for garments and textiles sector, 0.026 for electronics and electric appliances sector, 0.020 for automotive sector, 0.172 for other manufacturing sector, 0.003 for mining sector, and 0.687 for service sector.

Productivity parameter

13. In the IDE-GSM, each industry in each region has a different productivity parameter. The productivity would reflect education and skills level, logistics infrastructure within the region, availability and quality of electricity and water supply, and firm equipment and congestion. To estimate the parameter, first, the productivity parameter is calibrated by sector and by region to replicate actual regional GDP in 2010. For every year in the model, it is assumed that each country raises the productivity parameter so that the growth rate of each country can be reproduced in the model. Since the forecast by IMF's World Economic Outlook is available until 2023, calibration of the productivity growth rate is made to fit to the forecast. From 2023 onward, the growth rate of productivity is assumed to decrease gradually at a pace wherein the growth rate decreases by half in 20 years, when the country has positive growth rate up to 2023. The growth rate of productivity is assumed as 0 after 2023 when the growth rate of the country is negative until 2023.

Elasticities of substitution between any two differentiated manufactured and service goods

14. The elasticity of substitution is uniformly determined for each industry, and the value is assumed to be identical for all the regions. The parameters are adopted from various literature, particularly from Hummels (1999), in which the values are calculated from international trade data. The parameter values used in IDE-GSM are as follows: 3.8 for agriculture sector, 5.1 for food processing sector, 8.4 for garments and textiles sector, 6.0 for electronics and electric appliances sector, 4.0 for automotive sector, 5.3 for other manufacturing sector, and 5.6 for mining sector. The value for service sector is defined as 3.0, the lowest among all the sectors, as services is defined as highly differentiated in IDE-GSM.

Speed of switching jobs within a location and speed of migration between regions

15. The parameters of speed of switching jobs within a region is set as 0.05 and the speed of migration between regions is set as 0.02. These values are based on historical data in Japan and countries in Southeast Asia.

Parameters for the service sector

16. The study assumes the transport costs for services as the fare of passengers who travel to consume or supply services. The fare per kilometer for each mode of transport for 15 passengers who can travel on the footprint of 20-foot container is estimated, in order to make it comparable to the transport costs for other industries. Elasticity of services are obtained by estimating the gravity equation for services trade, using the following independent variables: importer's GDP, exporter's GDP, importer's corporate tax, geographical distance between countries, a dummy variable for free trade agreements, a linguistic commonality dummy, and the colonial dummy. The elasticity for services is obtained from the transformation of a coefficient for the corporate tax as it changes prices of services directly. For this estimation, data from Organisation for Economic Co-operation and Development Statistics on International Trade in Services is used.

C. Simulation Procedure

17. Figure A1 explains the simulation procedures. First, with given distributions of employment and regional GDP by sector and regions, short-run equilibrium is obtained. The equilibrium nominal wages, price indices, output, and GDP by region are then calculated.

18. Observing the achieved equilibrium, workers migrate from the regions with lower real wages to those with higher real wages. Within a region, workers move from lower-wage industries to higher-wage industries. Note that the process of this adjustment is gradual and the real wages between regions and industries are not equalized immediately.

19. After the migration process, new distribution of workers and economic activities are obtained. With this new distribution and predicted population growth, the next short-run equilibrium is obtained for the following year, and the study observes the migration process again. These computations are iterated typically for 20 years from 2010 to 2030 (Isono et al. 2016).

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Economic Impact Analysis of Improved Connectivity in Nepal

This study estimates and analyzes the economic impact of ongoing and future infrastructure development projects in Nepal by using the geographical simulation model developed by the Institute of Developing Economies (IDE-GSM). The IDE-GSM is a computational general equilibrium model based on spatial economics. The simulation analysis reveals that ongoing infrastructure development projects in Nepal benefit the country's economy, and that the planned connectivity improvement with India will have positive impact with anticipated major shift in mode of transport for trade. The study takes into consideration efforts by the Government of Nepal to promote and strengthen international connectivity under the South Asia Subregional Economic Cooperation framework.

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