Impact of International Transportation Infrastructure Development on a Landlocked Country: Case Study in the Greater Mekong Subregion

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Abstract: This paper analyzes the impact of international transportation infrastructure projects on a landlocked country. Landlocked countries/regions usually suffer from low economic development. Lao PDR, located in the Greater Mekong Subregion (GMS), is one of them. Currently, multiple international transportation infrastructure projects are in progress in the GMS, including cross-border land transportation development, port development, and cross-border trade facilitation. These projects are expected to contribute to the economic development of Lao PDR and other GMS members. This paper analyzes their impact using the standard Global Trade Analysis Project (GTAP) model. It is one of the spatial computable general equilibrium models with which to estimate the change in economic activities caused by transportation projects. The results show that the international transportation investment in the GMS substantially increases the GDP in Lao PDR in addition to the GDPs in other GMS members.

Key Words: *landlocked developing country, Lao PDR, Greater Mekong Subregion, spatial computable general equilibrium model, GTAP*

1. INTRODUCTION

Landlocked countries usually suffer from low economic development. Sachs and Warner (1997) point out that landlocked countries have lower steady-state incomes and therefore, lower growth from any initial level of GDP. Gallup *et al.* (1999) show that being landlocked reduces growth by at least half a percentage point. The World Bank (2009), however, mentions that being landlocked is no reason for poverty. For example, Switzerland, Luxembourg, and Austria are landlocked but not developing counties. Most landlocked countries tend to have two problems: poor neighbors and inaccessible markets. Poor neighbors would make few spillovers to the landlocked region while rich neighbors would be a market for the landlocked region and would allow the landlocked region to use their well-developed transportation infrastructure for international trade. The long distance from markets

results in higher transportation cost for the landlocked region. The higher transportation cost makes the landlocked region's goods less competitive in the market. It also weakens the purchasing power of the consumer in the landlocked region.

Lao PDR is a landlocked developing country that is surrounded by Thailand, Cambodia, Vietnam, China, and Myanmar. Lao PDR incurs high transportation costs to access the world markets. In 1992, under the initiative of the Asian Development Bank (ADB), Cambodia, China, Lao PDR, Myanmar, Thailand, and Vietnam entered into a program of economic cooperation in the Greater Mekong Subregion (GMS), designed to enhance economic relations among the countries. The program has contributed to infrastructure development that enables regional development and the sharing of the resource base and promotes the free flow of goods and people in the subregion. It has also led to international recognition of the subregion as a growth area. The program covers the following nine sectors: transportation, energy, telecommunications, environment, human resource development, tourism, trade, private sector investment, and agriculture. The transportation sector plays an important role in the program. Most of the transportation projects are classified into the following four categories: land transportation infrastructure development, facilitation of border crossing, port development, and airport development. The transportation projects in the GMS development program are expected to accelerate the development of Lao PDR by helping the country overcome the problem of transportation.

This paper analyzes the impact of the international transportation infrastructure projects in the GMS on Lao PDR. Note that this paper covers land and sea transportation, not air transportation. The paper estimates the economic impact using the standard Global Trade Analysis Project (GTAP) model. It is one of the spatial computable general equilibrium models with which to estimate the changes in economic activities caused by transportation projects.

A similar approach was adopted by Stone and Strutt (2009), who quantified the potential economic impact of land transportation infrastructure development and border crossing facilitation in the GMS. Some of the key linkages between upgraded infrastructure, economic growth, and sectoral responses are explored using a spatial computable general equilibrium framework. The study provides a static view of one-off gains from a conservative estimate of a reduction in transportation costs and improvements in trade facilitation. The results show that Lao PDR and other GMS members enjoy welfare and GDP growth thanks to the GMS development program. The intra-GMS trade increases while trades between GMS members and non-GMS countries generally decrease. However, Stone and Strutt (2009) did not cover the following three issues. First, they did not take into consideration the improvement of sea transportation between the GMS members and the rest of the world. A number of ports in the GMS are now under development. The improvement of sea transportation between the GMS members and the rest of the world might have a negative impact on Lao PDR. For example, Thailand and Vietnam, relatively developed countries in the GMS, may enhance their trade with the rest of the world rather than with Lao PDR, due to port development. Thus, this paper incorporates the sea transportation to and from GMS explicitly. Second, Stone and Strutt (2009) did not consider the difference between transportation modes. Although multiple transportation modes are widely used in the GMS, Stone and Strutt (2009) assumed that the same level of service improvement is uniformly given to all transportation modes. This might bias the evaluation results. Thus, this paper considers explicitly the difference in level-of-service among transportation modes. Finally, Stone and Strutt (2009) analyzed the economic impact using a database that contained information available as of the year 2004. As the GMS

has been developing drastically, a more current database on the international economy should be used for the analysis rather than the 2004 database to evaluate the projects. Thus, this paper uses the estimated results in 2020 for a baseline scenario.

The paper is organized as follows. Section 2 includes overviews of Lao PDR and the GMS development program. Section 3 introduces the methodology, including the spatial computable general equilibrium model and the future international economy forecast method. Section 4 describes the scenarios used in the scenario analysis after explaining the expected reductions in transportation time and cost. Section 5 presents and discusses the results of the scenario analysis. Finally, Section 6 concludes the paper and highlights further research issues.

2. OVERVIEWS OF LAO PDR AND THE GMS DEVELOPMENT PROGRAM

2.1 Overview of Lao PDR

Lao PDR is a landlocked developing country located in the GMS. Its population is 6.21 million as of 2008. Its Gross Domestic Product is USD 5.2 billion and the growth rate is 7.5 percent. The Gross National Income per capita based on purchasing power parity is USD 2,040 (see **Table 1**). Lao PDR is classified as a Least Developed Country by The United Nations Committee for Development Planning.

Table 1: Basic information of Lao PDR (2008)

Surface Area	236,800 square km
Population	6.21 million
Gross domestic product (GDP)	USD 5.20 billion
Annual growth rate of GDP	7.5%
Gross national income per capita	USD 2,040

Source: World Development Indicators database (September 2009)

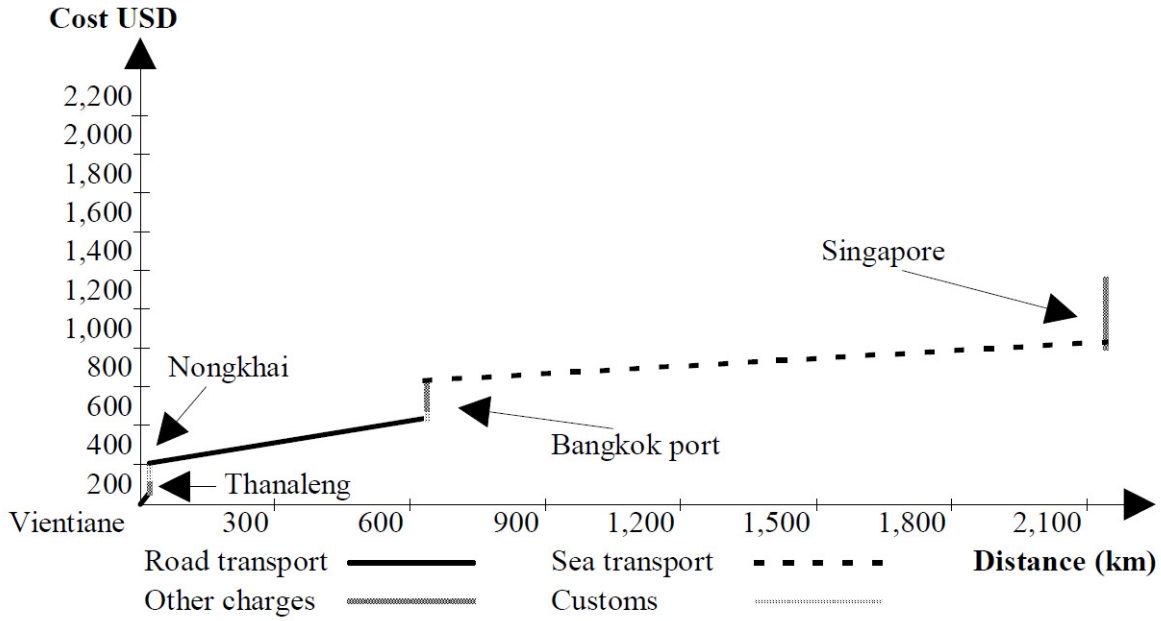

Figure 1: Cost of freight transportation from Vientiane to Singapore per TEU
Source: Banomyong (2001)

Figure 1 graphically illustrates how the transportation cost increases when freights are carried on road from Vientiane to Bangkok Port, and shipped by sea to Singapore. Prices quoted concern the shipment of one Twenty-Foot Equivalent Unit (TEU) on a Freight All Kind (FAK) basis. The total cost is USD 1,215 and the total time is 6/7 days. Road transportation represents 30 percent of the total transportation cost whereas sea transportation has a ratio of 19 percent. Other costs are charged for border crossing. As **Figure 1** shows, the transportation costs before leaving Bangkok Port represent half of the total costs of moving goods to market. Border crossing costs occupy a major share while road and sea transportation costs represent a small portion of overall costs. If the freight were carried in Thailand, the cross-border cost from Lao PDR to Thailand, of about two hundred USD, would not be charged.

2.2 Overview of the GMS Development Program

Infrastructure development of land transportation and facilitation of border crossing are carried out along the three economic corridors in the GMS. During the Eighth GMS Ministerial Meeting held in Manila in 1998, three economic corridors were identified to connect infrastructure development with investment activities and then to effectively promote regional economic development. As shown in **Figure 2**, the three economic corridors include East-West Economic Corridor (EWEC), Southern Economic Corridor (SEC), and North-South Economic Corridor (NSEC). The EWEC extends from Da Nang in Vietnam to Mawlamyline in Myanmar, crossing the central area of Lao PDR and the northern part of Thailand. Main routes of the NSEC connect Kunming and Bangkok via Lao PDR and Myanmar. Main routes of the SEC connect Bangkok, Phnom Penh and Ho Chi Minh City.

In addition to the current framework of cross-border facilitation, the Ministry of Land, Infrastructure, Transport and Tourism, Japan (2008) suggests the potential to facilitate further border crossing. For example, the introduction of Information and Communication Technology (ICT), such as logistics management using Radio Frequency Identification and the Global Positioning System, could advance cross-border facilitation. ICT will drastically reduce cross-border procedures in the GMS countries by intensively administrating the cross-border transportation flows.

The GMS development program includes ports development as well. As shown in **Table 2**, there are development projects at ports in Thailand, Vietnam, Cambodia, and Myanmar. New ports slated for development are Lien Chieu Seaport, Cai Mep-Thi Vai deepwater port, and Van Phong Port in Vietnam and Dawei deepwater port in Myanmar. Upgrades of existing ports are also planned. Most of the upgrading projects aim to enhance capacity, improve cargo handling, and increase accessibility to land transportation.

Figure 2: GMS Economic Corridors
Source: ADB (2009a)

Table 2: Port development projects in the GMS

Country	Project	Implementation Schedule	Type
Thailand	Laem Chabang, Phase 2, Construction of C and D Container Terminals	2006–2010(proposed)	Upgrade
Vietnam	Da Nang Port at Tien Sa	2001–2004	Upgrade
	Haiphong Port	1994–(ongoing)	Upgrade
	Cai Lan Port	1996–(ongoing)	Upgrade
	Da Nang Port Upgrading (Phase 2)	2007–2008(proposed)	Upgrade
	Lien Chieu Seaport	(proposed)	New Port
	Vung Tau port rehabilitation	(ongoing)	Upgrade
	Upgrading of Can Tho Port	(proposed)	Upgrade
	Cai Mep–Thi Vai deepwater port	(ongoing)	New Port
	Development of Van Phong Port in Khanh Hoa Province	(proposed)	New Port
Cambodia	Sihanoukville port expansion, construction of container terminal	2002–(ongoing)	Upgrade
	Phnom Penh port development and expansion *	–2020 (proposed)	Upgrade
Myanmar	Yangon–Thilawa Port Improvement/Development Project	(ongoing)	Upgrade
	Development of Kyaukpyu Deep Sea Port **	–	Upgrade
	New Dawei deepwater port	(proposed)	New Port

Source: ADB Website *Source: JICA *et al.* (2007) **Source: ASEAN (2007)

3. METHOD

3.1 Spatial Computable General Equilibrium Model

The standard GTAP model is used for the scenario analysis with the GTAP database version 7 (Hertel, 1997). The model is one of the spatial computable general equilibrium models, with which the changes in economic activities caused by transportation projects are estimated. It covers multiple sectors in multiple regions, with the assumptions of perfect competition and constant returns to scale. The database covers a publicly available global database, which contains complete bilateral trade information, transportation, and protection linkages among 113 regions for all 57 commodities in a single year. Note that the GTAP 7 database contains the data for 2004. For analytical simplicity and for the purpose of our analysis, the 113 original regions are aggregated into 38 regions (see Appendix 1) while the 57 original commodities are aggregated into 17 commodities (see Appendix 2).

First, the international economy in 2020 is forecasted with the GTAP model and the database version 7. This result is regarded as a baseline scenario. Then, the changes in economic activities in each country are estimated by inputting the expected reduction in transportation time and cost into the GTAP model. Although the GTAP model in itself does not include transportation time, the reduction in transportation time is incorporated into the model by assuming the iceberg transportation cost (Samuelson, 1952). This is because the transportation time, most of which is time involving border procedures, could have a great effect on international trade volume (OECD, 2003).

3.2 Forecasts of Baseline Scenario in 2020

The baseline scenario in 2020 is estimated by following Shibasaki *et al.* (2010). In this scenario, the changes in the following factors in each region are estimated: population, skilled labor, unskilled labor, capital, natural resource, and GDP. The international economy in 2020 is estimated by the sequential three simulations. The first simulation estimates the changes from 2004 to 2010 by inputting the changes in the above factors into the GTAP model with the data from 2004. Next, the second simulation estimates the changes from 2010 to 2015 by inputting the changes in the above factors into the GTAP model with the data for 2010 estimated by the first simulation. Finally, the third simulation estimates the changes from 2015 to 2020 by inputting the changes in the above factors into the GTAP model with the data for 2015 estimated by the second simulation. It should be noted that the other factors including tariff rates are assumed to be constant in those simulations.

The changes in the above factors in the three simulations are estimated as follows. First, the changes in regional populations are estimated based on the population forecasted by the United Nations (2007) and CEPD (2008). Next, the populations of skilled labor and unskilled labor are estimated by using the population between 15 and 64 years old forecasted by the United Nations (2007) and CEPD (2008). It is assumed that the share of skilled labor and unskilled labor is constant in each region. Then, the annual growth rate of capital is assumed to be 50 percent of the annual growth rate of real GDP while the production of natural resources is assumed to increase by 2 percent annually. These assumptions follow Shibasaki *et al.* (2010). Finally, the change in real GDP is assumed based on Ministry of Land, Infrastructure, Transport, and Tourism, Japan (2004) and International Monetary Fund (2008). The details of data assigned to the GTAP model in the simulations are shown in **Table 3**.

4. SCENARIOS

4.1 Expected Reductions in Transportation Time and Cost

The expected reductions in transportation time and cost for land transportation and sea transportation in the GMS are reviewed from past research. They will be utilized in our scenario analysis.

4.1.1 Land Transportation

First, JETRO (2007) estimates the reductions in land transportation time and cost between Bangkok and Hanoi resulting from the introduction of the Second Thai-Lao Friendship Bridge. The bridge was constructed in December 2006 as a part of the EWEC connecting Mukdahan in Thailand with Savannakhet in Lao PDR. Without the bridge, it was required to detour via Nongkhai-Vientiane crossing the First Thai-Lao Friendship Bridge and it took at least four days and USD 2,500 per TEU. JETRO (2007) shows that these are expected to decrease to three days and USD 2,110 by changing the route to a new route via the Second bridge (see **Table 4**).

Next, Banomyong (2007) estimates the reduction in time and cost of the following three routes owing to the development of the NSEC: Bangkok-Kunming route, Haiphong-Kunming route, and Nanning-Hanoi route (see **Table 5**). NSEC has two routes on the road connecting Bangkok with Kunming: one route is via Myanmar and the other route is via Lao PDR. Additionally, Banomyong (2007) estimates the share of the cross-border time and transportation time out of the total transportation time (see **Table 6**).

Table 3: Changes in the factors input into the GTAP model in the three simulations

	Population			*Unskilled labor*			*Skilled labor*			*Capital*			*Natural resources*			*Change in real GDP*		
	2004–2010	2010–2015	2015–2020	2004–2010	2010–2015	2015–2020	2004–2010	2010–2015	2015–2020	2004–2010	2010–2015	2015–2020	2004–2010	2010–2015	2015–2020	2004–2010	2010–2015	2015–2020
jpn	–0.13	–0.9	–1.67	–4.13	–5.45	–4.01	–4.13	–5.45	–4.01	3.7	3.1	2.6	12.62	10.4	10.4	7.42	6.1	5.1
kor	2.02	0.91	0.21	4.3	1.67	–1.77	4.3	1.67	–1.77	17.55	12.9	12.9	12.62	10.4	10.4	35.55	25.8	25.8
hkg	6.19	4.38	3.82	6.98	3.04	–1.43	6.98	3.04	–1.43	36.75	30.5	30.5	12.62	10.4	10.4	28.01	27.6	27.6
prc	3.53	2.74	2.35	6.41	2.55	–0.21	6.41	2.55	–0.21	13.86	13.8	13.8	12.62	10.4	10.4	75.23	61.1	61.1
twn	2.29	1.54	1.04	2.29	1.54	1.04	2.29	1.54	1.04	13.86	11.4	11.4	12.62	10.4	10.4	28	22.8	22.8
xea	11.26	9.44	3.85	8.06	4.82	3.27	8.06	4.82	3.27	29.21	13.8	13.8	12.62	10.4	10.4	59.57	27.6	27.6
phl	12.09	8.7	7.58	15.18	11.09	9.15	15.18	11.09	9.15	14.95	15.3	15.3	12.62	10.4	10.4	30.23	30.7	30.7
vnm	8.26	6.19	5.38	14.97	7.77	4.86	14.97	7.77	4.86	21.41	21.4	21.4	12.62	10.4	10.4	43.47	42.9	42.9
tha	4.05	2.52	1.84	5.55	2.18	0.44	5.55	2.18	0.44	17.55	16.9	16.9	12.62	10.4	10.4	35.55	33.8	33.8
mys	10.7	7.62	6.57	14.46	9.12	7.51	14.46	9.12	7.51	20.62	16.9	16.9	12.62	10.4	10.4	41.85	33.8	33.8
sgp	7.38	4.71	3.24	20.68	3.7	–1.78	20.68	3.7	–1.78	17.55	15.3	15.3	12.62	10.4	10.4	35.55	30.7	30.7
idn	7.23	4.99	4.09	9.59	6.96	5.81	9.59	6.96	5.81	21.8	19.1	19.1	12.62	10.4	10.4	44.28	38.3	38.3
lao	11.26	9.44	3.85	8.06	4.82	3.27	8.06	4.82	3.27	13.14	13.8	13.8	12.62	10.4	10.4	26.53	27.6	27.6
cmb	11.26	9.44	3.85	8.06	4.82	3.27	8.06	4.82	3.27	13.14	13.8	13.8	12.62	10.4	10.4	26.53	27.6	27.6
mmr	11.26	9.44	3.85	8.06	4.82	3.27	8.06	4.82	3.27	13.14	13.8	13.8	12.62	10.4	10.4	26.53	27.6	27.6
xse	11.26	9.44	3.85	8.06	4.82	3.27	8.06	4.82	3.27	13.14	13.8	13.8	12.62	10.4	10.4	26.53	27.6	27.6
bgd	10.55	8.09	7.34	14.44	10.27	8.2	14.44	10.27	8.2	16.05	19.1	19.1	12.62	10.4	10.4	32.49	38.3	38.3
ind	9.14	6.75	5.89	13.07	9.27	7.43	13.07	9.27	7.43	27.51	23.5	23.5	12.62	10.4	10.4	56.06	46.9	46.9
lka	2.87	1.96	1.35	4.32	0.54	1.33	4.32	0.54	1.33	18.31	13.8	13.8	12.62	10.4	10.4	37.1	27.6	27.6
xsa	11.26	9.44	3.85	8.06	4.82	3.27	8.06	4.82	3.27	24.62	16.9	16.9	12.62	10.4	10.4	50.07	33.8	33.8
xme	11.26	9.44	3.85	8.06	4.82	3.27	8.06	4.82	3.27	20.23	15	15	12.62	10.4	10.4	41.05	30.1	30.1
med	3.89	2.49	1.9	5.54	2.78	1.72	5.54	2.78	1.72	11.01	13.8	13.8	12.62	10.4	10.4	22.21	27.6	27.6
eur	1.13	0.67	0.5	1.31	–0.97	–1.56	1.31	–0.97	–1.56	4.02	3.3	3.3	12.62	10.4	10.4	8.06	6.7	6.7
rus	–3.02	–2.74	–2.98	–0.7	–4.33	–5.11	–0.7	–4.33	–5.11	18.69	15.3	15.3	12.62	10.4	10.4	37.88	30.7	30.7
xsu	11.26	9.44	3.85	8.06	4.82	3.27	8.06	4.82	3.27	19.46	15.7	15.7	12.62	10.4	10.4	39.46	31.3	31.3
afr	12.46	9.94	9.61	14.89	12.58	12.94	14.89	12.58	12.94	20.62	15	15	12.62	10.4	10.4	41.85	30.1	30.1
usa	5.97	4.55	4.11	6.01	3.15	2.16	6.01	3.15	2.16	6.28	6	6	12.62	10.4	10.4	12.62	12	12
can	5.53	4.26	3.97	6.45	2.65	1.22	6.45	2.65	1.22	8.95	7.4	7.4	12.62	10.4	10.4	18.02	14.8	14.8
mex	6.98	4.95	4.15	10.05	7.04	4.95	10.05	7.04	4.95	12.07	12	12	12.62	10.4	10.4	24.36	24	24
xna	11.26	9.44	3.85	8.06	4.82	3.27	8.06	4.82	3.27	9.63	12.9	12.9	12.62	10.4	10.4	19.41	25.8	25.8
xcm	11.26	9.44	3.85	8.06	4.82	3.27	8.06	4.82	3.27	10.32	11.4	11.4	12.62	10.4	10.4	20.8	22.8	22.8
per	7.17	6.49	5.76	10.16	7.94	7.02	10.16	7.94	7.02	22.6	18.5	18.5	12.62	10.4	10.4	45.91	37	37
chl	6.21	4.62	3.98	9.02	4.72	2.67	9.02	4.72	2.67	14.95	13.8	13.8	12.62	10.4	10.4	30.23	27.6	27.6
xap	11.26	9.44	3.85	8.06	4.82	3.27	8.06	4.82	3.27	10.32	11.4	11.4	12.62	10.4	10.4	20.8	22.8	22.8
sae	7.82	5.65	4.88	9.39	6.56	5.11	9.39	6.56	5.11	10.32	11.4	11.4	12.62	10.4	10.4	20.8	22.8	22.8
aus	6.25	4.84	4.56	6.39	3.05	2.4	6.39	3.05	2.4	9.97	9.7	9.7	12.62	10.4	10.4	20.1	19.3	19.3
nzl	5.53	4.01	3.57	6.5	2.91	2.22	6.5	2.91	2.22	7.27	7.7	7.7	12.62	10.4	10.4	14.62	15.4	15.4
xoc	11.26	9.44	3.85	8.06	4.82	3.27	8.06	4.82	3.27	11.01	6.8	6.8	12.62	10.4	10.4	22.21	13.7	13.7

Finally, Nathan Associates (2007) estimates the expected reduction in transportation time and costs of the two routes under the condition that the performance of logistics systems improves so that it reaches the international norm. The estimated results are shown for the route between Vientiane and Laem Chabang port (see **Table 7**) and the route between Danang and Mukdaharn (see **Table 8**).

Table 4: Estimated reductions in transportation time and cost of the Bangkok-Hanoi route after the start of Second Thai-Lao Friendship Bridge

	Section		Distance (km)	Time	Average Speed (km/h)	Cost for Transportation (US$)
Land Trans-port	Bangkok–Khon Kaen	Thailand	419	5 hours	83.8	-
	Khon Kaen–Nhon Khai		180	3 hours	60	-
	Vientiane–Savanakhet	Lao PDR	450	6 hours	75	-
	Savanakhet–Densavanh		214	3 hours	71.3	-
	Lao Bao-Dong Ha	Vietnam	82	2 hours	41	-
	Dong Ha–Vinh		290	3 hours 50 mins	75.7	-
	Vinh–Hanoi		290	5 hours 30 mins	52	-
	Total		**1,961**	**4 days**	**-**	**2,500**
	(After January 2007)					
	Khon Kaen–Mukdahan	Thailand	260	3 hours 45 mins	69.3	-
	Total		**1,591**	**3 days**		**2,110**
Sea	Bangkok–Hai Phong Port		-	10-15 days	580	1,000

Source: JETRO (2007)
Note: Transport cost is for a TEU, excluding import and export custom fee.

Table 5: Estimated reductions in time and cost after the start of NSEC

Route	Year	Cost per ton (USD)	Transit time (hours)
Bangkok-Kunming via Myanmar	2000	639	77
	2015	269	30
Bangkok-Kunming via Lao PDR	2000	563	78
	2015	210	30
Haiphong-Kunming	2000	105	85
	2015	43	26.5
Nanning-Hanoi	2000	37	37
	2015	9	8

Source: Banomyong (2007)
Note: The data in 2015 are estimated based on the full construction of transportation infrastructure and implementation of the CBTA.

Table 6: Estimated share of transportation time in the total time in the NSEC by route

Route	Transportation and Distribution	Border Crossing	Total
Bangkok-Kunming via Myanmar	80%	20%	100%
Bangkok-Kunming via Lao PDR	85%	15%	100%
Haiphong-Kunming	50%	50%	100%
Nanning-Hanoi	63%	37%	100%

Source: Banomyong (2007)

Table 7: Comparisons of cost and time along the routes from Vientiane to Laem Chabang port (export from Lao PDR)

	Cost to shipper		Time to shipper	
	Actual	Norm	Actual	Norm
Port and terminal operations	70	50–150	3.5 days	3–5 days
Seaport customs	0	0–50	0.5 hour	0.5–1.5 hours
Rail transportation	35	0–50	3.5 hours	2.5–3.5hours
ICD operations	62.5	10–30	2.5 days	1–2 days
Road transportation	845	200–300	16 hours	12–15 hours
Transloading	50	50–150	2 hours	2–4 hours
Inland customs	180	100–300	3 hours	2–4 hours
Export formalities	120	50–150	12 days	3–5 days
Total	1,362	820 (average)	18.5 days	10.5 days (average)

Source: Nathan Associates (2007)

Table 8: Comparisons of time and cost along the routes from Danang port to Mukdaharn (import to Lao PDR)

	Cost to shipper		Time to shipper	
	Actual	Norm	Actual	Norm
Import formalities	200	50–150	10 days	2–3 days
Port and terminal operation	107	50–150	0.5 days	0.5–2 days
Seaport customs	262	50–150	1 day	1–3 days
Road transportation	581	120–180	10.5 hours	0.5–1 day
River crossing	132	50–100	3.5 hours	2–4 hours
Transloading	316	50–150	2 hours	2–4 hours
Inland customs	28	100–300	1 hours	2–4 hours
Total	1,626	825 (average)	12 days	7 days (average)

Source: Nathan Associates (2007)

4.1.2 Sea Transportation

Unfortunately, few studies have examined the expected reductions in transportation time and cost for sea transportation in the GMS resulting from the port development. Therefore, this paper assumes that the efficiency level of port operations in the GMS is improved to the efficiency level of port operations in developed countries. This means that the process time at the ports in the GMS to import and/or export goods is assumed to be reduced to the process time at the ports in developed countries. Note that China is excluded from this assumption because it does not have any port development project in the GMS program.

According to the Doing Business database 2009 published by the World Bank, the export/import processes are classified into the following four categories: “documents preparation,” “customs clearance and technical control,” “ports and terminal handling,” and “inland transportation and handling.” Our analysis defines the time to export or import at ports to be the sum of process time in “customs clearance and technical control,” “ports and terminal handling,” and “inland transportation and handling.” Note that “customs clearance

Table 9: Current process time to export and import at ports in major countries

(Days)	Time to export	Time to import
Thailand	6	5
Lao PDR	17	17
Vietnam	10	9
Cambodia	8	11
China	7	9
Japan	6	6
Singapore	4	2
US	4	3
UK	5	4

Source: Doing Business Database 2009 (World Bank)
Note 1: Time to import/export includes "customs clearance and technical control," "ports and terminal handling," and "inland transportation and handling."
Note 2: Data for Myanmar are not available in the database.

and technical control" and "ports and terminal handling" are also considered in land transportation. The current process time to export and import at ports in major countries is shown in **Table 9**.

4.2 Development of Scenarios

Four scenarios are prepared for the scenario analysis. The conditions applied to the land transportation in the four scenarios are summarized in **Table 10** while the conditions applied to the sea transportation in the four scenarios by country are summarized in **Table 11**. First, Scenario 1 describes the case where the land transportation projects in the GMS have been completed. It is assumed that the land transportation time among the GMS members is uniformly reduced by 30 percent while the land transportation cost among the GMS members is uniformly reduced by 45 percent. Note that the process time to export/import to and from Lao PDR is reduced for sea transportation whereas the time to export/import to and from other countries is not reduced. This is because the improvement of the cross-border land transportation will reduce the sea transportation time in addition to the land transportation time.

Second, Scenario 2 presents the case where only port development projects in the GMS have been completed. It is assumed that the process time to export out of and import into Vietnam, Cambodia, and Myanmar is reduced to five days, which is close to the process time at ports in developed countries. It should be noted that the process time in Thailand is reduced, not to five days but to four days exceptionally. This is because the ports in Thailand already have a more modernized trade system than do other GMS members.

Third, Scenario 3 shows the case where both land transportation projects and port development projects in the GMS have been completed. Here, it is assumed that the process time to export/import to and from Lao PDR is reduced by eight days. This follows Nathan Associates (2007), which shows that the expected reduction in transportation time of the route from Vientiane to Laem Chabang port is eight days.

Table 10: Conditions of time and cost of land transportation in the scenario analysis

Scenarios	Time	Cost
Scenario 1	Reduction by 30%	Reduction by 45%
Scenario 2	-	-
Scenario 3	Reduction by 30%	Reduction by 45%
Scenario 4	Reduction by 40%	Reduction by 45%

Table 11: Conditions of process time to export/import at ports by sea transportation in GMS countries in the scenario analysis

(days)		Thailand	Lao PDR	Vietnam	Cambodia	Myanmar	China
Time to export	2009	6	17	10	8	8	7
	Scenario 1	6	11	10	8	8	7
	Scenario 2	4	15	5	5	5	7
	Scenario 3, 4	4	9	5	5	5	7
Time to import	2009	5	17	9	11	11	9
	Scenario 1	5	10	9	11	11	9
	Scenario 2	4	16	5	5	5	9
	Scenario 3, 4	4	9	5	5	5	9

Note: Data for Myanmar are not available in the database, so they are assumed to be equal to Cambodia.

Finally, Scenario 4 assumes the case where further cross-border facilitation is carried out in addition to Scenario 3. Land transportation time in the GMS is reduced further than in Scenario 3, by 40 percent.

4.3 Analytical Assumptions in the GTAP Model for Scenario Analysis

4.3.1 Reductions in Transportation Cost

The reductions in transportation cost are reflected by changing a technology-related coefficient in the GTAP model. The quantity of goods transported by a specific mode satisfies the following equation in the GTAP model:

$$QTMFSD^{*}(i,r,s,m) = \{1 + atmfsd(i,r,s,m)\} \times QTMFSD(i,r,s,m) \quad (1)$$

where $QTMFSD^{*}(i,r,s,m)$ is the quantity of commodity *i* imported from region *r* to region *s* by mode *m*; $QTMFSD(i,r,s,m)$ is the quantity of commodity *i* exported from region *r* to region *s* by mode *m*; and $atmfsd(i,r,s,m)$ is the technical change coefficient on transportation of commodity *i* from region *r* to region *s* by mode *m*. This reflects the assumption of the iceberg transportation cost, in which transporting a good uses up only some fraction of the good itself rather than using any other resources. The technical coefficient is regarded as the efficiency of transporting goods. In the GTAP model, the variable *atmfsd* is defined for each commodity, each bilateral trade, and each mode. Then, the increase in *atmfsd* by 20 percent causes a 20 percent increase in the quantity of commodity imported by the corresponding mode.

4.3.2 Reductions in Transportation Time

The GTAP model in itself does not include the variables of transportation time. Thus, the

reductions in transportation time are reflected in the GTAP model by using an approach introduced by Hertel *et al.* (2001) and Minor and Tsigas (2008). The approach adopts again the assumption of the iceberg transportation cost, which identifies reduction in transportation time with an increase of the traded commodity.

To incorporate the transportation time, the variable *atmfsd* is formulated by multiplying the reduction in transportation time with a tariff equivalent for value of time. This means:

$$atmfsd(i,r,s,m) = TE(i,s) \times \Delta DAYS(r,s,m) \tag{2}$$

where
$TE(i,s)$: Tariff equivalent for value of time per day for commodity *i* imported by region *s* (% ad-valorem); and
$\Delta DAYS(r,s,m)$: Change in transportation time of mode *m* for the bilateral trade from region *r* to region *s*.

The tariff equivalent for value of time per day is calculated by aggregating the data of Hummels *et al.* (2007) to match the aggregated 17 commodities and services and the aggregated 38 importing regions. Hummels *et al.* (2007) estimated the value of time per day for each 4-digit Harmonized System (HS) code-based commodity. Its average is 0.8 percent ad-valorem. The Tariff Analytical and Simulation Tool for Economists (TASTE) is used to modify the 4-digit HS code classification into the GTAP classification. TASTE divides 4-digit HS code-based commodities into a GTAP-classified commodity in a bilateral trade. The value of time per day for each GTAP commodity and each importing region is calculated by aggregating original data according to the share presented by TASTE (see Appendix 3 for details).

The change in transportation time is defined as:

If *m* = land transportation,

$$\Delta DAYS(r,s,m) = \{EXDAY(r) + IMDAY(s)\} * TIMEREDRATE(r,s,m) \tag{3}$$

If *m* = sea transportation,

$$\Delta DAYS(r,s,m) = EXDAYRED(r,m) + IMDAYRED(s,m) \tag{4}$$

where
$EXDAY(r)$: Days to export in region *r* (Source: Doing Business Database 2009);
$IMDAY(s)$: Days to import in region *r* (Source: Doing Business Database 2009);
$TIMEREDRATE(r,s,m)$: Time reduction rate regarding transportation from region *r* to *s* by mode *m*;
$EXDAYRED(r,m)$: Reduced days to export in region *r* by mode *m*; and
$IMDAYRED(s,m)$: Reduced days to import in region *s* by mode *m*.

5. RESULTS

5.1 Results of Scenario Analysis

Table 12 presents the changes in real GDP in the GMS countries in the four scenarios with the real GDPs in the baseline scenario in 2020. First, all GMS members enjoy GDP growth in all scenarios. This means that the international transportation infrastructure development projects in the GMS impart great benefit to every country in the GMS. Second, the estimated

results show that the GDP growth rate is higher in Lao PDR and in Cambodia than the GDP growth rate in other countries. This is mainly because Lao PDR and Cambodia depend on the other GMS members for their trade more than the others do. This probably indicates that the cross-border transportation projects in the GMS contribute to the improvement of the national economy, particularly in the low-income countries that depend on the external effects from neighbor regions. Third, the GDP growth rate in Lao PDR is positive in Scenario 2 as well as in Scenario 1. This means that the port development in neighbor countries contributes to the GDP growth even without the improvement of land transportation. This probably reflects the external effect of infrastructure investment in neighborhood regions on the landlocked country. Fourth, the GDP growth rate in Lao PDR is 4.82 percent in Scenario 1 while it is 0.70 percent in Scenario 2. This is because Lao PDR is more dependent on land transportation than on sea transportation. On the contrary, the GDP growth rate of Cambodia is 0.28 percent in Scenario 1 while it is 5.82 percent in Scenario 2. This is because Cambodia owns some ports where the port management is potentially improved. Fifth, the GDP growth rates in Scenario 4 are higher than the GDP growth rates in Scenario 3 in all countries while the GDP growth rates in Scenario 3 are higher than the GDP growth rates in Scenarios 1 and 2 in all countries. This simply reflects the improvement levels of transportation service in the Scenarios. Finally, China and Thailand have relatively smaller GDP growth rates than other countries. Thailand gains 0.26 percent growth in Scenario 1, 0.49 percent in Scenario 2, 0.75 percent in Scenario 3, and 0.83 percent in Scenario 4. China enjoys only 0.02 percent growth in Scenario 1, 0.03 percent in Scenario 2, 0.05 percent in Scenario 3, and 0.06 percent in Scenario 4. The low growth rate is due to China's and Thailand's trading less with other GMS members than the others do.

Tables 13, 14, 15, and 16 show the changes in international trades between the GMS members and the rest of the world in Scenarios 1, 2, 3, and 4, respectively.

Table 12: Real GDP changes in the GMS countries in the four Scenarios

		Vietnam	Thailand	Lao PDR	Cambodia	Myanmar	China
Baseline scenario in 2020	GDP (million USD)	74,657	287,535	3,718	6,585	10,763	3,984,447
Scenario 1	GDP change (%)	+2.77	+0.26	+4.82	+0.28	+1.25	+0.02
Scenario 2	GDP change (%)	+2.14	+0.49	+0.70	+5.82	+1.42	+0.03
Scenario 3	GDP change (%)	+4.62	+0.75	+5.71	+6.19	+2.60	+0.05
Scenario 4	GDP change (%)	+5.40	+0.83	+6.02	+6.24	+2.97	+0.06

Note: GDPs are estimated with the price as of 2020.

Table 13: Changes in international trade of the GMS members in Scenario 1

	Vietnam	Thailand	Lao PDR	Cambodia	Myanmar	China	ROW
Vietnam		+0.6%	+53.4%	+0.6%	–17.6%	+44.7%	–5.4%
Thailand	–9.5%		+20.0%	+2.4%	+19.3%	+0.2%	–0.3%
Lao PDR	+14.5%	+43.8%		+17.5%	–20.0%	+11.2%	–11.6%
Cambodia	+44.4%	+88.9%	–10.4%		–13.8%	–2.3%	–2.1%
Myanmar	–10.9%	+12.8%	–9.1%	–1.1%		+31.1%	–3.1%
China	+38.8%	+9.6%	+4.5%	–0.3%	+16.0%		–0.4%
ROW	–12.3%	–1.9%	+8.4%	+2.1%	–10.5%	+0.0%	+0.0%

Note: ROW means Rest of the World.

Table 14: Changes in international trade of the GMS members in Scenario 2

	Vietnam	Thailand	Lao PDR	Cambodia	Myanmar	China	ROW
Vietnam		+6.9%	+8.1%	+21.8%	+32.6%	+20.1%	+2.5%
Thailand	+17.6%		–0.1%	+10.1%	–6.7%	+3.6%	+0.2%
Lao PDR	–0.2%	–0.4%		+17.5%	+20.0%	–0.2%	+0.8%
Cambodia	–1.2%	+2.5%	+6.9%		+20.7%	+10.6%	+3.5%
Myanmar	+18.8%	–3.6%	–9.1%	+9.9%		+5.5%	+5.8%
China	–4.9%	+3.0%	–0.2%	+1.3%	–2.6%		+0.0%
ROW	+11.4%	+3.0%	+2.7%	+3.8%	+10.7%	–0.3%	–0.1%

Note: ROW means Rest of the World.

Table 15: Changes in international trade of the GMS members in Scenario 3

	Vietnam	Thailand	Lao PDR	Cambodia	Myanmar	China	ROW
Vietnam		+8.2%	+65.5%	+22.2%	+10.1%	+64.2%	–2.7%
Thailand	+7.8%		+19.9%	+12.9%	+11.7%	+3.8%	–0.1%
Lao PDR	+15.5%	+42.9%		+32.2%	–16.0%	+13.4%	–10.0%
Cambodia	+46.2%	+95.0%	–2.9%		+5.5%	+7.6%	+1.2%
Myanmar	+5.3%	+8.7%	+9.1%	+7.1%		+42.0%	+2.0%
China	+34.0%	+12.8%	+5.1%	+1.0%	+13.6%		–0.4%
ROW	–1.2%	+1.1%	+11.5%	+5.9%	–0.5%	–0.3%	+0.0%

Note: ROW means Rest of the World.

Table 16: Changes in international trade of the GMS members in Scenario 4

	Vietnam	Thailand	Lao PDR	Cambodia	Myanmar	China	ROW
Vietnam		+8.0%	+67.3%	+22.0%	+4.8%	+75.3%	–4.1%
Thailand	+5.0%		+23.0%	+13.4%	+15.4%	+3.9%	–0.2%
Lao PDR	+23.7%	+56.6%		+25.9%	–16.0%	+20.1%	–13.8%
Cambodia	+55.4%	+107.9%	+1.9%		+2.8%	+7.0%	+0.9%
Myanmar	+2.8%	+10.6%	+9.1%	+6.9%		+52.8%	+1.4%
China	+42.2%	+14.9%	+8.3%	+0.9%	+17.0%		–0.5%
ROW	–4.0%	+0.6%	+9.9%	+6.3%	–3.1%	–0.3%	+0.0%

Note: ROW means Rest of the World.

First, **Table 13** shows that in Scenario 1, the trades from one country to neighbor countries increase by a high percentage, for example, the trade from Cambodia to Thailand and from Vietnam to Lao PDR. This reflects the improvement of cross-border transportation caused by the time reduction in land transportation service.

Second, interestingly, **Table 13** shows that in Scenario 1, the trade from the ROW to Lao PDR increases by 8.4 percent while the trade from Lao PDR to the ROW decreases by 11.6 percent. More consumption goods are imported from out of GMS to Lao PDR, mainly because the land transportation projects improve accessibility from the international market to Lao PDR. The goods from Lao PDR are exported not out of the GMS but to the GMS members, probably because the sharp economic growth in neighbor countries including Thailand and Cambodia attracts the goods exported from Lao PDR.

Third, **Table 14** shows that the trades between the GMS and the ROW increase except for the trade from the rest of the world to China in Scenario 2. This is contrastive to the results of Scenario 1, in which most of the trades between the GMS and the ROW decrease. This is because the port development promotes the trade between the GMS and the ROW.

Fourth, **Table 14** also shows that the trades between Lao PDR and the ROW increase because of the port development in neighbor countries without the improvement of land transportation. This is probably because of the external effect of the development of neighbor countries. This means that the infrastructure development in the neighborhood regions contributes to improving the accessibility of the landlocked region to the international market.

Fifth, **Table 14** further shows that in Scenario 2, the trades between non-neighbor countries in the GMS increase by a higher percentage, for example, the trades between Thailand and Vietnam; Myanmar and Vietnam; and Cambodia and Myanmar; while some trades between neighbor countries decrease, such as the trades between Lao PDR and Thailand and between Myanmar and Thailand. Additionally, the unbalanced changes are observed, for example, the trade from Lao PDR to Vietnam decreases while the trade from Vietnam to Lao PDR increases.

Sixth, **Table 15** shows that the results in Scenario 3 are almost equal to the sum of the results of Scenario 1 and 2. The impact of Scenario 1 may be larger than the impact of Scenario 2. The trades to Lao PDR increase except for the trade from Cambodia to Lao PDR while the trades from Lao PDR also increase except for the trades from Lao PDR to Myanmar and to the ROW.

Finally, **Table 16** shows that the trade from Lao PDR to Myanmar decreases even in Scenario 4 although other trades among the GMS members increase. This may mean that it is quite difficult to increase all trades in the GMS through the international transportation infrastructure development.

Tables 17, **18**, **19**, and **20** show the estimated changes in output by industry in the GMS members in Scenarios 1, 2, 3, and 4 respectively, while **Table 21** shows the output in the GMS members estimated in the baseline scenario for 2020. **Table 17** shows that the change in output in Lao PDR is the highest among the GMS members in Scenario 1. This is supported mainly by the development of grains and mining industries. It should be noted that the outputs

Table 17: Estimated changes in output by industry in Scenario 1

Industry	Vietnam	Thailand	Lao PDR	Cambodia	Myanmar	China
Grains	–1.4%	+0.0%	+4.2%	–0.1%	+0.8%	+0.0%
VegtFrut	+0.2%	–0.6%	+0.0%	+0.8%	–1.1%	+0.0%
OthCrops	–2.9%	–0.2%	–3.9%	+0.6%	–0.8%	+0.0%
MeatLstk	+3.9%	+0.2%	–13.9%	+0.3%	+1.0%	+0.0%
Forestry	–2.4%	–0.8%	–0.2%	+3.8%	–1.7%	+0.0%
Fishing	+1.7%	+0.0%	+1.9%	+0.0%	+1.6%	+0.0%
Mining	+0.6%	–0.2%	+51.0%	+1.0%	+1.2%	–0.1%
ProcFood	–1.2%	+0.0%	–2.8%	–0.8%	+0.7%	+0.0%
TextWapp	+1.1%	–0.9%	–22.1%	–2.2%	+2.7%	+0.0%
LightMnfc	–2.6%	–0.2%	+5.6%	+3.0%	+1.8%	+0.0%
HeavyMnfc	–3.6%	–0.4%	+12.4%	+10.9%	–8.1%	+0.1%
Util_Cons	+3.9%	+0.6%	+11.4%	+0.9%	+1.5%	+0.0%
TransNec	+1.9%	+0.0%	–4.7%	–0.3%	+0.8%	+0.0%
SeaTrans	+3.5%	–0.3%	–8.9%	+0.2%	+2.7%	+0.0%
AirTrans	+3.9%	–0.7%	–5.2%	–0.9%	+2.6%	–0.1%
TransComm	–1.8%	+0.1%	+5.2%	+0.1%	+0.3%	+0.0%
OthServices	+0.8%	+0.1%	+2.9%	–0.1%	+0.9%	+0.0%
Total	+11.3%	–2.3%	+48.5%	+17.4%	+9.8%	–0.2%

Note: The definitions of industries are shown in Appendix 2.

Table 18: Estimated changes in output by industry in Scenario 2

Industry	Vietnam	Thailand	Lao PDR	Cambodia	Myanmar	China
Grains	–2.1%	–1.8%	+0.5%	–0.1%	+0.3%	+0.0%
VegtFrut	+0.3%	+0.3%	+0.4%	–0.5%	–0.6%	+0.0%
OthCrops	–4.1%	–0.5%	+0.1%	–2.0%	–0.1%	+0.1%
MeatLstk	+3.7%	–0.1%	–2.3%	–5.0%	–0.2%	+0.0%
Forestry	–2.2%	–0.6%	–0.2%	–0.4%	–0.5%	+0.0%
Fishing	+1.5%	–0.2%	+0.4%	–0.4%	–0.1%	+0.0%
Mining	+0.9%	–1.5%	+0.7%	–1.6%	–1.2%	–0.1%
ProcFood	–1.8%	–1.2%	+0.0%	–6.4%	+0.3%	+0.0%
TextWapp	–0.2%	–2.7%	+0.2%	+2.8%	+9.7%	+0.0%
LightMnfc	+1.1%	–0.6%	–1.3%	+2.3%	+0.4%	+0.0%
HeavyMnfc	–3.8%	+0.5%	+1.6%	–10.4%	–4.6%	+0.0%
Util_Cons	+4.5%	+2.3%	+1.1%	+10.2%	+1.3%	+0.0%
TransNec	+0.5%	–0.8%	–0.4%	–4.3%	+3.7%	+0.0%
SeaTrans	+1.5%	–2.5%	–0.7%	–1.1%	+5.3%	+0.0%
AirTrans	+1.5%	–4.8%	–0.4%	–5.8%	+5.3%	+0.1%
TransComm	–3.1%	+0.2%	+0.4%	–1.7%	+0.5%	+0.0%
OthServices	–0.7%	–0.2%	+0.2%	+0.6%	+0.3%	+0.0%
Total	+4.3%	–11.1%	+2.0%	–8.3%	+22.0%	+0.2%

Note: The definitions of industries are shown in Appendix 2.

Table 19: Estimated changes in output by industry in Scenario 3

Industry	Vietnam	Thailand	Lao PDR	Cambodia	Myanmar	China
Grains	–3.4%	–1.8%	+4.9%	–0.2%	+1.1%	+0.0%
VegtFrut	+0.4%	–0.3%	+0.5%	+0.4%	–1.7%	+0.0%
OthCrops	–6.9%	–0.6%	–3.3%	–1.3%	–1.0%	+0.1%
MeatLstk	+7.3%	+0.2%	–18.0%	–4.9%	+0.8%	+0.0%
Forestry	–4.6%	–1.4%	–0.4%	+3.4%	–2.3%	+0.0%
Fishing	+3.0%	–0.2%	+2.5%	–0.4%	+1.5%	+0.0%
Mining	+1.6%	–1.7%	+58.0%	–0.9%	+0.1%	–0.2%
ProcFood	–3.0%	–1.2%	–2.6%	–7.2%	+0.9%	+0.0%
TextWapp	+0.8%	–3.7%	–21.8%	+0.4%	+11.9%	+0.0%
LightMnfc	–1.7%	–0.9%	+4.3%	+5.6%	+2.1%	–0.1%
HeavyMnfc	–7.1%	+0.1%	+14.8%	+0.9%	–12.2%	+0.1%
Util_Cons	+8.0%	+2.9%	+12.9%	+11.2%	+2.8%	+0.0%
TransNec	+2.1%	–0.7%	–4.7%	–4.5%	+4.5%	+0.0%
SeaTrans	+4.6%	–2.8%	–9.4%	–0.8%	+8.0%	+0.0%
AirTrans	+4.9%	–5.4%	–5.5%	–6.6%	+7.9%	+0.0%
TransComm	–4.8%	+0.4%	+5.8%	–1.6%	+0.8%	+0.0%
OthServices	+0.2%	–0.1%	+3.1%	+0.6%	+1.1%	+0.0%
Total	+13.3%	–13.4%	+58.6%	+10.0%	+31.4%	–0.1%

Note: The definitions of industries are shown in Appendix 2.

Table 20: Estimated changes in output by industry in Scenario 4

Industry	Vietnam	Thailand	Lao PDR	Cambodia	Myanmar	China
Grains	–3.7%	–1.8%	+5.1%	–0.2%	+1.3%	+0.0%
VegtFrut	+0.5%	–0.4%	+0.7%	+0.6%	–1.9%	+0.0%
OthCrops	–7.6%	–0.7%	–5.3%	–1.2%	–1.3%	+0.0%
MeatLstk	+8.2%	+0.1%	–16.3%	–4.8%	+1.0%	+0.0%
Forestry	–5.3%	–1.5%	+0.1%	+4.0%	–2.8%	+0.0%
Fishing	+3.4%	–0.2%	+2.3%	–0.4%	+1.4%	+0.0%
Mining	+2.0%	–1.8%	+57.2%	–0.8%	+0.5%	–0.2%
ProcFood	–3.6%	–1.2%	–3.2%	–7.3%	+1.0%	+0.0%
TextWapp	+0.8%	–3.8%	–27.3%	+0.0%	+12.3%	+0.0%
LightMnfc	–2.5%	–0.9%	+6.7%	+6.1%	+2.1%	–0.1%
HeavyMnfc	–8.0%	+0.0%	+14.1%	+2.9%	–13.9%	+0.1%
Util_Cons	+8.8%	+3.0%	+13.5%	11.4%	+3.1%	+0.0%
TransNec	+2.5%	–0.7%	–5.9%	–4.5%	+5.0%	+0.0%
SeaTrans	+5.4%	–2.8%	–11.1%	–0.8%	+9.0%	+0.0%
AirTrans	+5.7%	–5.5%	–6.6%	–6.7%	+8.8%	–0.1%
TransComm	–5.3%	+0.4%	+6.1%	–1.6%	+1.0%	+0.0%
OthServices	+0.5%	–0.1%	+3.5%	+0.6%	+1.4%	+0.0%
Total	+15.0%	–13.8%	+51.9%	+13.1%	+33.6%	–0.1%

Note: The definitions of industries are shown in Appendix 2.

Table 21: Estimated output in the baseline scenario in 2020 (million USD)

Industry	Vietnam	Thailand	Lao PDR	Cambodia	Myanmar	China
Grains	7,607	14,872	1,104	765	3,424	156,266
VegtFrut	2,319	6,740	397	238	1,478	213,764
OthCrops	2,150	3,923	51	218	99	28,347
MeatLstk	7,130	12,291	795	825	177	306,143
Forestry	1,716	916	262	148	861	78,073
Fishing	2,398	4,388	202	403	185	71,064
Mining	10,157	8,379	58	219	1,557	365,454
ProcFood	9,207	26,236	876	708	2,263	296,166
TextWapp	15,822	25,107	252	3,771	1,043	598,189
LightMnfc	35,070	70,691	354	1,480	699	1,438,663
HeavyMnfc	36,189	149,922	222	983	1,234	4,198,019
Util_Cons	22,369	77,971	476	1,063	1,916	926,502
TransNec	1,469	23,856	227	513	38	309,643
SeaTrans	1,224	3,148	33	121	87	146,264
AirTrans	1,546	5,876	50	425	102	38,444
TransComm	4,107	67,629	394	1,124	379	962,981
OthServices	22,504	119,801	1,032	2,222	2,078	1,693,279
Total	182,982	621,746	6,786	15,226	17,621	11,827,259

Note: The definitions of industries are shown in Appendix 2.

in heavy manufacturing and in utilities and construction increase by 12.4 percent and 11.4 percent, respectively, while the outputs in livestock and meat products and in textiles and clothing decrease by 12.9 percent and 22.1 percent, respectively. This may mean that the industrial structure in Lao PDR is changed by the international transportation project in Scenario 1 from a resource-production-oriented industrial structure to a manufacture-oriented industrial structure. Similar changes in the industrial structure of Lao PDR are also observed in Scenarios 3 and 4, as shown in **Tables 19** and **20**.

Table 18 shows that the output in Myanmar increases at the highest rate while the output in Thailand decreases at the highest rate in Scenario 2. The industry in Lao PDR is not greatly affected in Scenario 2.

5.2 Discussions

First, the scenario analysis shows that the international transportation projects in the GMS will accelerate the development of Lao PDR and the other GMS members by enhancing economic integration among the GMS members. The economic impact on Lao PDR is particularly higher than that on other countries. This is mainly because the transportation time and cost to and from Lao PDR are more significantly reduced by the transportation projects than in the case of other countries. The significant reductions in the transportation time and cost result in high economic growth in Lao PDR in the following two ways. The first way is that the reductions in transportation time and cost enable the local industries and/or consumers in Lao PDR to purchase more goods imported from other countries at lower prices. As local industries can save the input cost by using cheaper imported goods, they can increase the outputs. The second is that the reductions in transportation time and cost improve the accessibility to markets in other countries. This increases the exports from the local industries and leads to the increase of outputs in Lao PDR.

Second, the results of Scenario 2 show that the port development in neighborhood regions increases the GDP in Lao PDR as well as the trades between Lao PDR and the rest of the world. This may reflect the external effect of the development of neighbor countries on the landlocked country.

Third, the international land transportation projects in the GMS decrease the trades between the GMS and the rest of the world while the port developments increase the trades between the GMS and the rest of the world. The results of the analysis in Scenario 3 indicate that the impact of land transportation projects is larger than the impact of port development projects.

Fourth, the international transportation projects stimulate the local economic activities in Lao PDR. Particularly, the mining industry increases its output by 51.0 percent, 58.0 percent, and 57.2 percent in Scenarios 1, 3, and 4, respectively.

Fifth, the international transportation projects may influence the industrial structure in local countries. The results of Scenarios 1, 3, and 4 show that the international transportation projects change the local industrial structures in Lao PDR. The outputs in heavy manufacturing and in utilities and construction increase, while the outputs in livestock and meat products and in textiles and clothing decrease.

6. CONCLUSIONS

This paper analyzed the impact of the GMS transportation projects on the local economy, including that of the landlocked country Lao PDR. The results show that they will surely accelerate the development of Lao PDR and the other GMS members by enhancing economic integration among them. The results indicate that the economic growth in Lao PDR is particularly significant. This means that the international transportation projects will help this landlocked country overcome its geographical barriers. More imports become available in Lao PDR because the market price of imports decreases, both from other GMS members and from the rest of the world. This enhances production and consumption in the country. In addition, the exports from Lao PDR become more competitive in foreign markets due to the reductions in time and cost. The results also show that the grain and mining industries in Lao PDR will be particularly developed. As transportation within the GMS improves more drastically than transportation between the GMS and the rest of the world, Lao PDR will shift their exports from the rest of the world to other GMS members. The increase in sales to other GMS members supports GDP growth in the country.

However, there is still room for improvement in this research. First, although the model in this paper examined the impact of the reduction in transportation time and cost, the impact of other factors including punctuality and/or reliability of international trade may also be significant. ADB (2009a) and ADB (2009b) point out that one of the problems with the GMS transportation is unreliability. The GMS transportation projects are expected to enhance the punctuality of freight transportation in the GMS in addition to reducing transportation time. The impact of improving punctuality should be evaluated. Second, although this paper analyzed the impact on international trade, it does not cover the impact of the GMS transportation projects on domestic transportation. As the domestic transportation industries sell their services to the international transportation sector, the improvement of international transportation has an indirect impact on the domestic transportation sector in addition to the

international transportation sector. This impact should also be covered. Third, the reduction in transportation time and cost of the trade between China and other GMS members may be overestimated. Although China is a member of the GMS, only Yunnan Province and Guangxi Zhuang Autonomous Region in China have projects that are part of the GMS program. Our analysis assumes that the GMS transportation projects have an impact on the whole of China for the sake of analytical simplicity. This assumption should be reexamined. Finally, this analysis does not cover the expected negative impact on Lao PDR. JICA and ALMEC (2007) point out that the transportation projects may additionally have a negative impact on the country through the increase of through-traffic flows, resulting in more traffic accidents and traffic noise. Although these external effects are not reflected in the analysis of this paper, they should be examined.

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Appendix 1: Aggregation of the Regions

Code	Aggregated regions	Original GTAP regions
jpn	Japan	Japan
kor	Korea	Korea
hkg	Hong Kong	Hong Kong
prc	China	China
twn	Taiwan	Taiwan
xea	Rest of East Asia	Rest of East Asia
phl	Philippines	Philippines
vnm	Vietnam	Viet Nam
tha	Thailand	Thailand
mys	Malaysia	Malaysia
sgp	Singapore	Singapore
idn	Indonesia	Indonesia
lao	Lao PDR	Lao People's Democratic Republic
cmb	Cambodia	Cambodia
mmr	Myanmar	Myanmar
xse	Rest of SEA	Rest of Southeast Asia
bgd	Bangladesh	Bangladesh
ind	India	India
lka	Sri Lanka	Sri Lanka
xsa	Rest of South Asia	Pakistan, Rest of South Asia
xme	Middle East	Armenia, Azerbaijan, Georgia, Iran Islamic Republic of, Turkey, Rest of Western Asia
med	Mediterranean	Cyprus, Greece, Italy, Malta, Portugal, Slovenia, Spain, Egypt, Morocco, Tunisia, Rest of North Africa
eur	Europe	Austria, Belgium, Czech Republic, Denmark, Finland, France, Germany, Hungary, Ireland, Luxembourg, Netherlands, Poland, Slovakia, Sweden, United Kingdom, Switzerland, Norway, Rest of EFTA, Albania, Bulgaria, Belarus, Croatia, Romania, Rest of Europe
rus	Russia	Russian Federation
xsu	Former Soviet	Estonia, Latvia, Lithuania, Ukraine, Rest of Eastern Europe, Kazakhstan, Kyrgyztan, Rest of Former Soviet Union
afr	Africa	Nigeria, Senegal, Rest of Western Africa, Central Africa, South Central Africa, Ethiopia, Madagascar, Malawi, Mauritius, Mozambique, Tanzania, Uganda, Zambia, Zimbabwe, Rest of Eastern Africa, Botswana, South Africa, Rest of South African Customs
usa	United States	United States of America
can	Canada	Canada
mex	Mexico	Mexico
xna	Rest of North America	Rest of North America
xcm	Central America	Costa Rica, Guatemala, Nicaragua, Panama, Rest of Central America, Caribbean
per	Peru	Peru
chl	Chile	Chile
xap	Rest of West of South America	Bolivia, Colombia, Ecuador
sae	East of South America	Argentina, Brazil, Paraguay, Uruguay, Venezuela, Rest of South America
aus	Australia	Australia
nzl	New Zealand	New Zealand
xoc	Rest of Oceania	Rest of Oceania

Appendix 2: Aggregation of Commodities

No.	Aggregated commodities	Original GTAP commodities
1	Grains	Paddy rice, Wheat, Cereal grains nec, Oil seeds, Sugar cane, Sugar beet, Processed rice
2	Vegetables and Fruit	Vegetables, Fruit, Nuts
3	Other Crops	Plant-based fibers, Crops nec
4	Livestock and Meat Products	Cattle, Sheep, Goats, Horses, Animal products nec, Raw milk, Wool, Silk-worm cocoons, Meat: Cattle, Sheep, Goats, Horse, Meat products nec
5	Forestry	Forestry
6	Fishing	Fishing
7	Coal Oil Gas Mineral	Coal, Oil, Gas, Minerals nec
8	Processed Food	Vegetable oils and fats, Dairy products, Sugar, Food products nec, Beverages and tobacco products
9	Textiles and Clothing	Textiles, Wearing apparel
10	Light Manufacturing	Leather products, Wood products, Paper products, Publishing, Metal products, Motor vehicles and parts, Transport equipment nec, Manufactures nec
11	Heavy Manufacturing	Petroleum, Coal products, Chemical, Rubber, Plastic prods, Mineral products nec, Ferrous metals, Metals nec, Electronic equipment, Machinery and equipment nec
12	Utilities and Construction	Electricity, Gas manufacture, distribution, Water, Construction
13	Transport nec	Transport nec
14	Sea Transport	Sea transport
15	Air Transport	Air transport
16	Trade and Communication	Trade, Communication
17	Other Services	Financial services nec, Insurance, Business services nec, Recreation and other services, PubAdmin/Defence/Health/Educat, Dwellings

Appendix 3: Tariff Equivalent for Value of Time Per Day (Percent ad-valorem)

TE(i,s), Tariff equivalent for value of time per day, for GTAP commodity *i* imported by region *s* (percent ad-valorem), is estimated as:

$$TE(i,s) = \sum_{j} \frac{\sum_{r} VXWD(j,r,s)}{\sum_{k}\sum_{s} VXWD(k,r,s)} \cdot TEHS(j) \quad j \in i \quad k \in i$$

where *VXWD(j,r,s)* is value of 4-digit HS code commodity *j* imported from region *r* to *s*, at world market price; and *TEHS(j)* is tariff equivalent for value of time per day with regard to 4-digit HS code commodity *j* (percent ad-valorem). Note that *TEHS(j)* is obtained from Hummels *et al.* (2007).

The tariff equivalent for value of time per day used in the scenario analysis is shown in the following table.

	1	2	3	4	5	6	7	8	9	10	11	12-17
1 JPN	0.31	1.33	0.23	0.57	0.19	0.39	2.08	0.78	0.64	0.97	0.85	0.00
2 KOR	0.21	1.11	0.08	0.77	0.30	0.33	2.24	0.84	0.63	0.87	1.03	0.00
3 HKG	0.11	0.92	0.16	1.68	0.20	0.36	1.85	0.88	0.63	1.07	0.94	0.00
4 PRC	0.85	2.23	0.14	0.81	0.19	0.47	3.74	0.74	1.09	1.12	0.89	0.00
5 TWN	0.43	0.82	0.37	0.74	0.25	0.43	2.20	1.16	0.66	1.08	0.82	0.00
6 XEA	0.10	1.41	0.52	2.52	0.37	0.21	2.14	1.07	0.71	1.11	1.27	0.00
7 PHL	0.30	0.45	0.07	0.32	0.63	0.76	1.91	1.44	0.82	1.31	0.81	0.00
8 VNM	0.14	0.38	0.20	1.15	0.48	0.30	1.55	1.32	0.84	1.08	1.25	0.00
9 THA	0.85	0.66	0.11	0.61	0.52	0.27	1.27	1.01	0.82	1.04	1.13	0.00
10 MYS	0.26	0.69	0.11	0.87	0.51	0.18	1.89	1.68	0.89	1.18	0.84	0.00
11 SGP	0.11	1.15	0.26	1.88	0.45	0.21	1.87	0.85	0.72	0.88	0.86	0.00
12 IDN	0.60	0.32	0.09	0.46	0.75	0.24	2.17	1.84	1.08	1.15	1.16	0.00
13 LAO	0.06	0.05	0.06	37.23	0.04	0.52	2.26	1.14	0.97	1.41	1.44	0.00
14 CMB	0.05	0.79	0.02	12.41	0.20	0.37	0.55	0.95	0.85	1.59	1.38	0.00
15 MMR	0.06	0.23	0.51	0.32	0.57	0.42	1.64	1.08	0.74	1.46	1.36	0.00
16 XSE	0.06	0.93	0.17	4.16	0.66	0.27	1.53	1.66	0.59	1.37	0.88	0.00
17 BGD	0.14	0.09	0.20	0.66	0.56	0.09	2.67	2.78	0.72	1.68	1.15	0.00
18 IND	0.15	0.20	0.45	0.53	0.74	0.17	1.62	1.37	0.81	0.80	3.89	0.00
19 LKA	0.05	0.13	0.20	1.42	0.18	0.16	3.54	1.38	0.66	1.61	1.72	0.00
20 XSA	0.15	0.33	0.81	3.43	0.22	0.33	2.59	1.59	0.95	1.01	1.53	0.00
21 XME	0.23	0.77	0.47	1.82	0.49	0.08	2.75	1.13	0.83	1.34	1.41	0.00
22 MED	0.38	0.97	0.11	0.80	0.35	0.13	2.57	0.91	0.68	1.40	1.17	0.00
23 EUR	0.44	1.11	0.13	0.96	0.20	0.15	1.86	1.03	0.70	1.24	1.03	0.00
24 RUS	0.06	1.07	0.20	0.52	0.44	0.09	2.48	0.99	0.77	1.26	1.02	0.00
25 XSU	0.10	0.77	0.26	0.71	0.14	0.07	1.25	1.16	0.81	1.16	1.15	0.00
26 AFR	0.05	0.35	0.26	1.27	0.11	0.27	2.80	1.15	0.71	1.30	1.29	0.00
27 USA	0.23	1.51	0.24	1.16	0.30	0.17	2.08	0.87	0.65	1.27	0.95	0.00
28 CAN	0.24	1.10	0.24	1.66	0.17	0.25	1.49	1.25	0.71	1.24	1.11	0.00
29 MEX	0.47	0.75	0.12	0.36	0.33	0.41	1.14	1.65	0.82	1.09	0.94	0.00
30 XNA	0.01	1.73	0.15	0.36	0.13	0.24	2.56	0.89	0.66	1.21	0.59	0.00
31 XCM	0.15	0.64	0.12	0.93	0.37	0.24	2.68	1.26	0.62	1.23	1.22	0.00
32 PER	0.08	0.56	0.04	0.40	0.55	0.18	2.35	1.38	0.78	1.47	1.29	0.00
33 CHL	0.21	1.77	0.40	0.15	0.78	0.95	0.96	1.85	0.75	1.33	1.17	0.00
34 XAP	0.27	0.67	0.11	0.83	0.41	0.16	2.01	1.59	0.93	1.52	1.11	0.00
35 SAE	0.45	0.67	0.10	0.54	0.61	0.15	1.51	1.35	0.87	1.14	1.01	0.00
36 AUS	0.24	0.63	0.31	0.57	0.43	0.30	2.37	1.08	0.67	1.36	1.40	0.00
37 NZL	0.07	1.63	0.30	0.93	0.29	0.61	1.04	1.32	0.68	1.49	1.17	0.00
38 XOC	0.06	0.45	0.84	0.32	0.35	1.14	3.19	0.94	0.75	1.03	1.19	0.00
Total	0.41	1.11	0.18	0.93	0.26	0.22	2.24	1.01	0.71	1.24	1.06	0.00

Row: Importing countries/regions
Column: Traded commodities
Note: Tariff equivalents of commodities from numbers 12 to 17 are set as zero because of a lack of data.