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**Assessing Socioeconomic Impacts
of Transport Infrastructure Projects
in the Greater Mekong Subregion**

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Abstract

This study attempts to quantify the links between infrastructure investment and poverty reduction using a multi-region general equilibrium model, supplemented with household survey data for the Greater Mekong Subregion (GMS). Infrastructure investment is an important step in economic development, with improvements in transportation infrastructure boosting economic opportunities throughout the region, for example by significantly reducing travel times and costs. In this study, we concentrate on quantifying the effects of some of the key linkages between upgraded infrastructure, economic growth, and poverty reduction. We model the impact of both reducing transport costs and improving trade facilitation in the GMS. Our findings suggest strong gains to the GMS countries as a result of infrastructure development and trade facilitation with national poverty reduced throughout the region. However, the impact on various segments of these populations differs, depending in part on factor returns.

Contents

1. INTRODUCTION AND BACKGROUND

Infrastructure development has an important role to play in economic development and poverty alleviation in the Greater Mekong Subregion (GMS). This study attempts to measure the links between infrastructure investment and poverty reduction using a multi-region general equilibrium model, supplemented with household survey data. Specifically, it examines how improvements in road infrastructure and the potential trade facilitation impacts of the Cross Border Transport Infrastructure (CBTI) agreement may impact household incomes in the GMS.

The GMS comprises Cambodia, Lao People's Democratic Republic (Lao PDR), Myanmar, Thailand, and Viet Nam, as well as Yunnan Province and Guangxi Zhuang Autonomous Region of the People's Republic of China (PRC). At the time of the inauguration of the GMS Economic Cooperation Program (1992), most of the region's infrastructure was of a very poor quality (Ishida 2007). In response to this, the GMS adopted the Transport Master Plan in 1995, which identified priority transport links—mostly road projects—designed to generate the greatest and most immediate improvements in connectivity. This was an important step in economic development, with improvements in transportation infrastructure boosting economic opportunities throughout the region, for example by significantly reducing travel times and costs. As the countries have moved away from a strategy of self sufficiency to one of regional cooperation, major efforts have been made to develop the infrastructure linking the GMS and beyond, particularly through the identification of ambitious economic corridor projects. These infrastructure projects have been supported by a number of international agencies, including the Asian Development Bank (ADB), in the hope that they will lead to significantly improved opportunities for the region.

Improved transportation infrastructure gives rise to complex economic interactions, with the exact casual relationship between economic growth and infrastructure investment unclear.[1] In this study, we attempt to quantify the effects of some of the key linkages between upgraded infrastructure, economic growth, and poverty reduction in the GMS. We use a computable general equilibrium framework that is particularly well-suited to this task, since it explicitly accounts for all sectors within an economy, as well as the interactions between them and with other economies. This framework enables us to quantify how the costs and benefits of improved infrastructure may be transmitted between markets and how they impact different household groups, including the implications for poverty alleviation.

We begin by outlining the nature of the economies and infrastructure issues in the GMS. We then introduce the global trade model and databases that are used to generate insights into some of the likely impacts of infrastructure development on GMS countries. This is followed by a discussion of the scenarios considered and the results of these, with a particular focus on medium-run and poverty impacts. We briefly discuss some potential negative impacts of infrastructure development before making some concluding remarks.

2. INFRASTRUCTURE AND DEVELOPMENT IN THE GMS

Almost 320 million people live in the GMS, which bridges South, Southeast, and East Asia. While ADB (2010) believes that "the Mekong region has the potential to be one of the world's fastest growing areas," economic development continues to elude some member countries and alleviating poverty remains a significant challenge. Infrastructure development has been shown to be an important mechanism to facilitate growth and development.[2] With this in mind, the GMS has pursued an agenda of comprehensive infrastructure improvement.

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[1] See Francois and Manchin (2007) for a discussion of the linkages between trade, infrastructure, and growth.

[2] For a review of infrastructure and growth in developing countries, see Straub (2008).

Table 1 presents summary data for the GMS. Populations range from just over 6 million people in the Lao PDR to over 90 million in the combined Yunnan/Guangxi region of the PRC. Likewise the economies range widely in size, with the value of gross domestic product (GDP) in the Lao PDR around US$5.5 billion while Thailand's GDP is almost 50 times as large, at over US$270 billion. GDP per capita ranges from under US$900 in Cambodia, Lao PDR, and Myanmar to over US$4,000 in Thailand. While there is variation across the GMS, overall it remains a relatively poor region, as shown by the World Bank poverty estimates in Table 1.

Table 1: Selected Aggregate Indicators for the GMS and PRC, 2008

	Population (mn)	GDP (US$ bn)	GDP per Capita (current US$)	GDP per Capita, PPP (current international $)	Poverty (% of population)[a]	Agriculture (% GDP)
Cambodia	14.6	10.4	711	1,951	25.8	34.6
Lao PDR	6.2	5.5	893	2,124	44.0	34.7
Myanmar	49.6	—	281[b]	838[b]	—	48.4[c]
Thailand	67.4	272.4	4,043	8,086	2.0	11.6
Viet Nam	86.2	90.6	1,051	2,787	21.5	22.1
PRC: Total	1,324.7	4,327.0	3,267	5,971	15.9	11.3
PRC: GMS[d]	92.3	75.4	—	—	—	—

GDP = gross domestic product; GMS = Greater Mekong Subregion; GNI = gross national income; Lao PDR = Lao People's Democratic Republic; PPP = purchasing power parity; PRC = People's Republic of China; US = United States.

[a] Poverty headcount ratio at US$1.25 per day (PPP), most recent year available: Cambodia 2007, Lao PDR 2002, Thailand 2004, Viet Nam 2006, PRC 2005.

[b] Data for 2005 (ADB 2008).

[c] Data for 2004.

[d] Yunnan and Guangxi: Population 2003, GDP 2004 (Akrasanee 2006).

Source: World Bank (2010), except as noted above.

As economies develop, they generally experience a structural shift away from a relative dependence on the agricultural sector and a movement into higher-valued areas of production. This shift can be observed in many of the GMS economies. For example, agriculture contributed approximately 39% of Viet Nam's GDP in 1990 but this had fallen to around 22% by 2008 (World Bank 2010). Despite this, GMS economies continue to rely relatively heavily on the agriculture sector; this is particularly the case in the lower-income countries, where the contribution of agriculture to the economy is much greater—almost 50% of GDP in the case of Myanmar (final column of Table 1). While the contribution of agriculture to output in the economy tends to decline over time, this does not undermine the importance of the agricultural sector for economic development. Binswanger and Lutz (2000) argue that because almost all nonfarm activities in rural areas are linked to agriculture, growth in agricultural demand is a necessary condition for rural growth. They suggest that rural regions cannot achieve sustained growth in agricultural demand unless they trade. Thus, improved transportation infrastructure, allowing rural regions to access export markets, can make an important contribution to agricultural trade and rural poverty reduction. Many agricultural products are produced by poor rural farmers who need access to roads in order to market their products effectively, particularly as products may deteriorate during transportation.

Poverty is multi-dimensional, and a range of different measures can reduce it;[3] however, regardless of the measure used, it remains predominantly a rural problem for most poor

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[3] For an overview, see Chapter 3 of McCulloch, Winters, and Cirera (2001).

countries, including in the GMS. Worldwide, over two thirds of the poor in developing countries live in rural areas, where poverty tends to be more acute in terms of income and nutritional status than in urban areas (e.g., Binswanger and Lutz 2000). The predominantly rural nature of poverty in the GMS is striking (Strutt and Lim 2005). Table 2 shows that for each GMS country, the rural population is more than 57% of the total population, with rural dwellers comprising almost 80% of the population in Cambodia. Given the importance of rural communities, a range of studies suggest that rural road investments are likely to bring particularly strong benefits for economic growth and poverty reduction (Jones 2006; Straub, Vellutini, and Warlters 2008). Connecting economic activities to the logistical hubs of the urban area is an important task for development.

**Table 2: Selected Geographic, Population, and
Infrastructure Indicators for the GMS, 2008**

	Land Area ('000 km^2)	Population Density (per km^2)	Rural Population (% total)	Road Density (per km^2)[a]	Paved Roads (% total)[a]	Rail Lines ('000 km)
Cambodia	177	82	78	22	6	0.7[b]
Lao PDR	231	27	69	13	13	—
Myanmar	654	76	67	4	12	—
Thailand	511	132	67	35	99	4.4
Viet Nam	310	278	72	49	48	3.1
PRC	9,327	142	57	36	71	60.8
GMS[c]	630.8	150.4				

Lao PDR = Lao People's Democratic Republic; PRC = People's Republic of China.

[a] PRC 2007; Cambodia 2004; Lao PDR 2006; Myanmar 2005; Thailand road density 2006, paved roads 2000; Viet Nam 2007.

[b] Cambodia 2005.

[c] Yunnan and Guangxi, source UNESCAP (2008), average population density calculated from 2000 data.

Source: World Bank 2010.

In terms of population density and land area, Table 2 indicates significant variation among GMS countries, with land area ranging from under 180 thousand square kilometers in the case of Cambodia to over 650 thousand square kilometers for Myanmar. Population density ranges from 27 people per square kilometer in the Lao PDR to over ten times this density in Viet Nam, at 278 people per square kilometer. It is notable that the poorest countries of Cambodia, Lao PDR, and Myanmar all have particularly limited road networks, with less than 15% of roads paved. These are also countries with relatively low population densities and limited resources to provide rural populations with access to markets and the accompanying opportunities.

Looking more specifically at land area and road coverage, the kilometers of road per square kilometer of land can be used as an indication of road density. For comparison, we present road density along with population density and include the United States (US), Japan, and the Euro Area. Results are shown in Figure 1, with the bars referring to road density and the line to population density. As the figure indicates, the population density for all GMS countries is well above road density (the exception being the Lao PDR). While the US and Viet Nam have very similar road density figures (49 kilometers per square kilometer of land for Vietnam and 68 for the US), their population densities per square kilometer are very different (278 for Viet Nam and 33 for the US). If one assumes that the developed regions shown have a roughly appropriate level of road networks, the substantial differences between the level of service in the GMS countries and the US, Japan, and the Euro Area provide some indication of the great need to expand transport networks within the GMS.

Figure 1: Road vs. Population Density
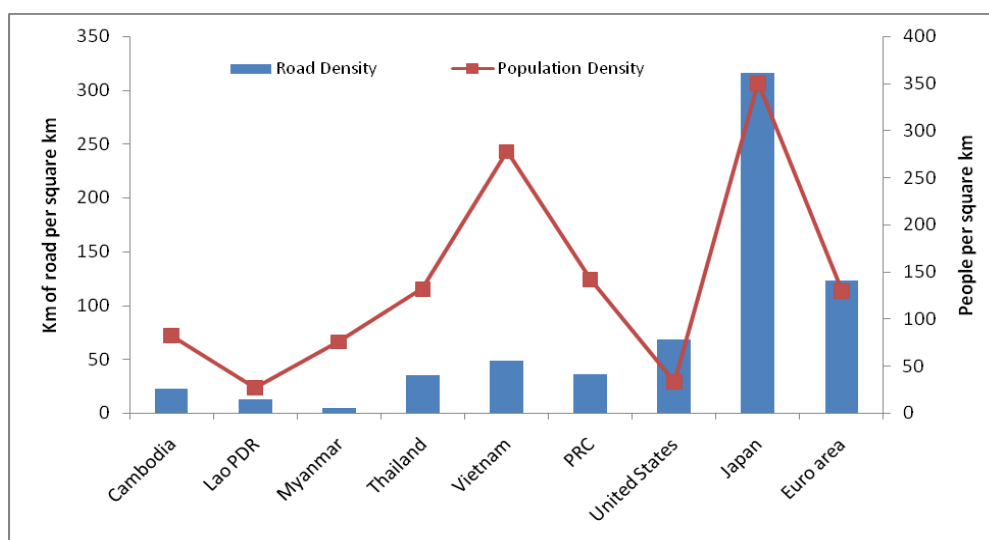
Lao PDR = Lao People's Democratic Republic; PRC = People's Republic of China; US = United States.

Population density is for 2008. Road density is: Cambodia 2004; Lao PDR 2006; Myanmar 2005; Thailand 2006; Viet Nam 2007; PRC 2007; US 2005; Japan 2007; Euro area 2005.

Source: World Bank 2010.

3. MODELING FRAMEWORK AND DATABASES

The current study aims to provide estimates of the impact of improvements in road transport infrastructure and the accompanying improvements in trade facilitation in the GMS. Economic modeling of transportation infrastructure improvements was undertaken using the Global Trade Analysis Project (GTAP) model. We started with the GTAP version 7 database (Narayanan and Walmsley 2008) and utilized this with a modified version of the standard GTAP model (Hertel et al. 2009). The multi-regional computable general equilibrium model and database used in this study are widely used internationally, fully documented, and publicly available (see GTAP 2010 for detailed information). We augmented this model and database to facilitate improved modeling of the GMS, including impacts on poverty.

3.1 The GTAP Model

The GTAP model draws on a set of economic accounts for each country or region, with interactions between regions and sectors captured within a consistent framework. The model we use is comparative and static and retains many standard features of the GTAP model (Hertel 1997). We modeled the behavior of private individuals, firms, and governments, along with responses to changing resource and market conditions. Consumers maximize welfare, subject to their budget limitations, while firms maximize profits using the limited resources available in the economy. In particular, primary factors of production are combined with intermediate inputs, including imports, to produce final output. Armington elasticities allow differentiation between imports from different countries in the GMS and elsewhere, specifying the extent to which substitution is possible between imports from various sources, as well as between imports and domestic production. When the impact of improved infrastructure and trade facilitation improvement is simulated, prices and quantities of marketed commodities, along with impacts on incomes and GDP, are endogenously determined within the model.[4] While retaining the simple yet empirically robust assumptions of constant returns to scale and perfect competition, Section 3.3 describes how we modified

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[4] The model was solved using GEMPACK software (Harrison and Pearson 1996), using the RunGTAP interface.

the model to shed new light on the distributional consequences of cross-border transport infrastructure projects.

3.2 The GTAP Database

We used version 7 of the GTAP database,[5] covering 113 countries or regions and 57 sectors, with a base year of 2004. This release of the GTAP database includes all of the GMS countries: Cambodia, Lao PDR, Myanmar, Thailand, and Viet Nam. While the PRC is available, Yunnan Province and Guangxi Zhuang Autonomous Region are not separated; therefore, we included the PRC in the modeling analysis. We aggregated the database in a way that maintains coverage of all GMS countries with relatively heavy disaggregation of sectors of key importance to the region and to poverty impacts. Details of the regional and commodity aggregation are in Appendixes 1 and 2.[6]

The level of trade between GMS economies varies a great deal, depending on the countries and commodities under consideration. Appendix 3 shows the value of intra-GMS trade, as estimated in the version 7 GTAP database. The country with the highest level of intra-GMS exports in the database is Myanmar, with over 40% of total exports going to other GMS countries. The Lao PDR sends over 28% of its exports to the GMS, though trade with Thailand dominates for both Myanmar and the Lao PDR. For Thailand and Viet Nam, 12–15% of exports are destined for GMS countries; however, exports to the PRC dominate. Excluding exports to the PRC, intra-GMS exports are only a little over 3% for Thailand and Viet Nam. Exports from Cambodia to other GMS countries, including the PRC, are relatively low at about 5%. As indicated in Appendix 3, in addition to variation by country, there is substantial variation by industry.

Of particular relevance to the current study are the international transportation margins included in the GTAP model and database. Margins are included in the database for air, water, and other transportation, with the latter including land transportation and therefore of key importance to our study. Appendix 4 shows the cost of bilateral GMS land transport margins as a proportion of the value of exports, calculated from the GTAP database. Cross-border land transport costs are likely to be relatively significant for poorer economies with less-developed infrastructure. This appears to be reflected to some extent in the database, with cross-border land transport margins within the region appearing most significant for the relatively poor countries of Cambodia, Lao PDR, and Myanmar.[7]

3.3 Analysis of Poverty Impacts

A general equilibrium approach is needed to predict changes in real earnings stemming from infrastructure improvements in the GMS. Transport infrastructure improvements will not have uniform impacts on poverty across the GMS and we use household survey data to augment the GTAP database so that the implications of infrastructure development for poverty may also be considered for Cambodia, Lao PDR, Thailand, and Viet Nam.[8]

3.3.1 Analytical Framework

There are many approaches to estimating the change in poverty headcount due to trade reforms (Winters, McCulloch, and McKay 2004; Hertel and Reimer 2005; Hertel and Winters 2006). The approach here builds on those outlined in Hertel et al. (2009), and begins with a

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[5] Candidate 2, released October 2008.

[6] Particular caution is order when considering data and results for Myanmar, given the quality of the underlying data.

[7] In the absence of available actual transportation cost data to produce a complete set of bilateral margins for the GTAP dataset, these transport margins are estimates (Gehlhar and McDougall 2006).

[8] Poverty assessments for Myanmar and the GMS areas of the PRC are not possible with current data availability.

consumer demand system and the associated utility function. The *poverty level of utility* was identified based on international poverty levels (using the World Bank's US$1 per day and US$2 per day poverty lines).[9] Our evaluation of poverty changes thus amounts to calculating the percentage of the population below this poverty level of utility.

We used Rimmer and Powell's (1996) AIDADS demand system (An Implicit Direct Additive Demand System) to represent consumption in the neighborhood of the poverty line. AIDADS is particularly useful for poverty analysis as it devotes two thirds of its parameters to consumption behavior in the neighborhood of the poverty line (Cranfield, Preckel, and Hertel 2006). Estimation of this demand system was undertaken using the per capita consumption dataset offered by GTAP version 7, with the demand system estimates then calibrated to reproduce base year per capita demands in each country.[10] From there, per capita income was shocked back to the international poverty line in order to identify the poverty level of utility and to estimate consumption quantities at the poverty line.

A key finding in the work of Hertel et al. (2004) is the importance of stratifying households by primary source of income. For example, farm households in developing countries may rely on the farm enterprise for virtually all of their income. And national poverty tends to be concentrated in agriculture-specialized households in the poorest countries in our sample. In these cases, the poor are more likely to benefit from farm price increases. In other countries, the national poverty headcount is dominated by wage earners who will be more susceptible to food price increases. To delineate the patterns of specialization in earnings, we followed Hertel et al. (2004) in identifying five household groups that rely almost exclusively (95% or more) on one of the following sources of income: agricultural self employment, non-agricultural self-employment, rural wage labor, urban wage labor, or transfer payments. The remaining households are grouped into rural and urban diversified strata, giving seven strata.[11]

Given our interest in comparing results across countries, we took a simplified approach to poverty analysis, focusing solely on the poverty headcount—at both the US$1 and US$2 per day levels. We did so by employing a survey-based *highly disaggregated* poverty elasticity-based analysis. In particular, we adopted from Hertel et al. (2009) the following equation for predicting the percentage change in poverty headcount, $\hat{H}_r$, in each of the GMS countries for which household survey data are available:

$$\hat{H}_r = -\sum_s \beta_{rs}\varepsilon_{rs}\sum_j \alpha_{rsj}^p \left(\hat{W}_{rj} - \hat{C}_r^p\right) \tag{1}$$

The term in parentheses on the right side of (1) reports the change in the after tax wage rate for endowment *j* in region *r*, $\hat{W}_{rj}$, relative to the change in the cost of living at the poverty line, $\hat{C}_r^p$. This real earnings term is pre-multiplied by several important parameters, which deserve additional discussion. The first of these is the share of earnings type *j* in total income of households in the neighborhood of the poverty line in stratum *s* of region *r*, α_{rsj}^p. This translates a change in, for example, the wage of unskilled labor, into a change in total household income. If wages rise by 10% and this is 95% of household income for households in the neighborhood of the poverty line in the rural wage labor stratum, then

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[9] The World Bank has recently released a new measure of poverty based on purchasing power parity and US$1.25 per day. This poverty line falls between our US$1 and US$2 measures. For more details on these changes, see World Bank (2010).

[10] These were estimated using a pre-release of the database with 96 countries available.

[11] A clear limitation of this approach stems from the rigidity of a given households' classification by earnings specialization. Obviously households maybe induced to change their specialization or diversify in response to changing relative factor returns. We believe that the relatively broad definition of strata circumvents this problem for the majority of households in the face of modest earnings changes.

income is predicted to rise by 0.95 * 10% = 9.5%. By definition, the earnings shares sum to one, i.e., $\sum_j \alpha_{rsj} = 1$, and summing over the share-weighted change in factor returns yields the total income change for households in the neighborhood of the poverty line for a given stratum or region combination.

This change in income is, in turn, multiplied by the estimated elasticity of the stratum-specific poverty headcount, H_{rs}, with respect to income, ε_{rs}. In order to turn these stratum changes into the estimated percentage change in national poverty headcount, they must be weighted by each stratum's share in national poverty:

$$\beta_{rs} = \left[(POP_{rs} * H_{rs}) / POP_r \right] / H_r = (POP_{rs} * H_{rs}) / \sum_k (POP_{rk} * H_{rk})$$

Summing across strata, we obtain the national poverty headcount reported in (1).

3.3.2   Integrating Poverty into the Model

To model poverty impacts within the GTAP framework, we introduced factor market segmentation, which is important in countries where the rural sector remains a dominant source of poverty (Keeney and Hertel 2005). Here, farm/nonfarm mobility is restricted by specifying a constant elasticity of transformation function that limits the mobility of labor and capital between the farm and nonfarm sectors. Therefore, farm and nonfarm factor returns may diverge, and this becomes a key driver for our distributional analysis. In order to parameterize these constant elasticity of transformation factor mobility functions, we drew on the OECD's (2001) survey of agricultural factor markets. We assumed a constant aggregate level of land, labor, and capital employment, reflecting the belief that the aggregate supply of factors is not overly affected by these transport projects, especially in the medium run.

Implementation of (1) required us to map factor earnings in the general equilibrium model to household income sources. Agricultural labor and capital received the corresponding farm factor returns from the general equilibrium model, as did non-agricultural labor and capital. Wage labor for diversified households reported in the surveys presented a problem because information was lacking to allocate it between agricultural and non-agricultural activities. We simply assigned to it the composite wage for labor determined by the constant elasticity of transformation endowment function. Finally, transfer payments were indexed by the growth rate in net national income.

3.3.3   Data and Elasticities

While conceptually simple, this approach to poverty analysis is actually quite data intensive. The household surveys for the Lao PDR and Cambodia were processed (Komoto 2009), and this, coupled with previously processed estimates for Viet Nam and Thailand (Hertel et al. 2004), permitted this approach to be implemented for these four countries in the GMS.

Table 3 reports the estimated earnings shares in the neighborhood of the US$1 per day poverty line in the four countries, α_{rsj}^p. Endowments are disaggregated into ten categories: agricultural land, self-employed agricultural labor (both unskilled and skilled), self-employed non-agricultural labor (both unskilled and skilled), wage labor (both unskilled and skilled), agricultural capital, non-agricultural capital, and transfer payments. The most difficult part of estimating these earnings shares derives from the need to impute returns to factors of production when the source of income is self-employment. This is achieved by matching self-employed household members with similar wage-earning individuals in the household survey and assigning the average earned wage for this class of workers (ideally, same sex and age, same skill level, same sector, same region). The residual earnings are assigned to

capital in the case of non-agricultural income and shared between capital and land in the case of farming.[12]

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[12] To split non-wage income between capital and land, we used the factor payment shares from the GTAP database, which are based on econometric studies of cost shares in agriculture.

Table 3: Household Earnings Shares, by Endowment Type, Stratum and Country: US$1 per Day (%)

Endowment	Agriculture	Non-Agriculture	Urban Labor	Rural Labor	Transfer Payments	Urban Diversified	Rural Diversified
Cambodia							
Ag. land	16.0	1.8	1.0	1.2	2.2	4.4	5.1
Ag. labor (unskilled)	72.5	0.0	0.0	0.0	0.0	19.1	26.7
Ag. labor (skilled)	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Non-ag. labor (unskilled)	3.5	84.6	0.0	0.0	0.0	19.5	19.3
Non-ag. labor (skilled)	0.0	0.0	0.0	0.0	0.0	6.6	4.8
Wage labor (unskilled)	3.3	0.0	46.4	50.3	0.0	20.2	17.2
Wage labor (skilled)	0.0	0.0	51.5	45.9	0.0	17.6	18.2
Agricultural capital	2.2	0.2	0.1	0.2	0.3	0.6	0.7
Non-ag. capital	1.3	11.7	0.0	1.0	0.0	3.9	3.0
Transfer payments	1.2	1.7	0.9	1.4	97.5	8.0	5.0
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Lao PDR	Agriculture	Non-Agriculture	Urban Labor	Rural Labor	Transfer Payments	Urban Diversified	Rural Diversified
Ag. land	9.4	0.0	0.0	0.0	0.1	2.4	3.6
Ag. labor (unskilled)	57.8	1.0	0.0	0.0	0.0	15.8	21.0
Ag. labor (skilled)	23.1	0.0	0.0	0.0	0.0	9.4	11.5
Non-ag. labor (unskilled)	1.6	31.8	0.0	0.0	0.0	15.6	14.2
Non-ag. labor (skilled)	0.0	33.0	0.0	0.0	0.0	14.5	11.0
Wage labor (unskilled)	1.9	1.8	50.7	39.4	0.0	12.5	9.0
Wage labor (skilled)	2.0	0.0	49.3	60.6	0.0	14.5	13.8
Agricultural capital	1.3	0.0	0.0	0.0	0.0	0.3	0.5
Non-ag. capital	1.8	32.4	0.0	0.0	0.0	8.4	9.6
Transfer payments	1.1	0.0	0.0	0.0	99.9	6.7	5.9
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Thailand	Agriculture	Non-Agriculture	Urban Labor	Rural Labor	Transfer Payments	Urban Diversified	Rural Diversified
Ag. land	8.2	0.0	0.1	0.0	0.1	1.9	4.1
Ag. labor (unskilled)	79.6	0.0	0.1	0.1	0.1	24.0	20.8
Ag. labor (skilled)	7.4	0.0	0.0	0.0	0.0	4.1	2.6
Non-ag. labor (unskilled)	0.0	90.8	0.0	0.0	0.0	3.8	3.1
Non-ag. labor (skilled)	0.0	6.2	0.0	0.0	0.0	0.4	0.7
Wage labor (unskilled)	0.3	0.4	98.0	97.8	0.7	28.1	23.6
Wage labor (skilled)	0.1	0.1	1.5	1.5	0.1	5.2	7.1
Agricultural capital	4.0	0.0	0.0	0.0	0.0	0.9	2.0
Non-ag. capital	0.0	2.3	0.0	0.0	0.0	1.3	1.5
Transfer payments	0.5	0.2	0.3	0.5	98.9	30.5	34.6
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Viet Nam	Agriculture	Non-Agriculture	Urban Labor	Rural Labor	Transfer Payments	Urban Diversified	Rural Diversified
Ag. land	3.1	0.0	0.0	0.0	0.0	3.8	1.0
Ag. labor (unskilled)	95.6	0.2	0.0	0.0	0.0	43.1	8.6
Ag. labor (skilled)	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Non-ag. labor (unskilled)	0.0	57.9	0.0	0.8	0.0	11.3	13.7
Non-ag. labor (skilled)	0.0	0.9	0.0	0.0	0.0	0.0	0.0
Wage labor (unskilled)	0.0	0.0	98.7	78.8	0.0	1.9	0.0
Wage labor (skilled)	0.0	0.0	0.0	18.3	0.0	0.0	0.0
Agricultural capital	1.4	0.0	0.0	0.0	0.0	1.7	0.4
Non-ag. capital	0.0	39.9	1.0	1.6	0.0	24.2	55.2
Transfer payments	0.0	1.1	0.3	0.5	100.0	14.0	21.0
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Lao PDR = Lao People's Democratic Republic.

Source: Author's calculations.

From Table 3, we can see a number of important points. In the case of the agricultural stratum, in which households earn more than 95% of their income from agricultural self-employment, the bulk of their income is imputed to unskilled labor income. The poor are poor, in part because they do not control a lot of productive assets. Returns to land and capital are most important in Cambodia, with very little residual remaining after wage imputation in Viet Nam. Non-agricultural, self-employed households (column 2) in the neighborhood of the poverty line appear to get more of their income from non-labor income. This is particularly true in Viet Nam, where this figure reaches 40%.

Turning to the wage labor households (columns 3 and 4), we see that the share of income coming from skilled labor is relatively high for Cambodia and the Lao PDR, the poorest of the four economies. This is perhaps not surprising, as increased education and training is often required in order to access the formal labor market. The rural and urban diversified households are just that—highly diversified. This diversification is further accentuated by the fact that we have created this earnings profile by taking all households within plus or minus 5% (i.e., 10% of the total stratum) of the poverty line in each stratum. This diversified group earns income from agricultural activities as well as nonfarm activities, receives transfer payments (quite significant in the case of Thailand), and receives income from capital (particularly in the case of Viet Nam).

As we have seen from equation (1), the earnings shares translate wage changes into income changes, but it is the poverty elasticities, ε_{rs}, that translate the latter into poverty changes, by stratum. Table 4 reports these stratum-specific poverty elasticities for the four countries. These are arc elasticities, obtained by examining the change in income as we move across the stratum decile surrounding the poverty line. We expect these elasticities to diminish as the total poverty headcount in the stratum rises (i.e., it is harder to reduce poverty by 1% when it represents 28% of the population, as in the Lao PDR, as opposed to less than 2% in Thailand). Accordingly, in Cambodia and the Lao PDR, the poverty elasticities are under 1.0 in all cases, while it is above 2.0 for all strata in Thailand (US$1 per day poverty line) and is nearly 9.0 in the rural labor stratum of Viet Nam, where there are many households clustered around the poverty line and the poverty headcount is relatively low (see below). For the same reason, the poverty elasticity tends to diminish as we move from US$1 per day to US$2 per day—there are simply more households below the poverty line.

Table 4: Poverty Elasticity, by Stratum and Region

	US$1 per Day			
Stratum	Cambodia	Lao PDR	Thailand	Viet Nam
Agriculture	0.64	0.58	2.30	0.48
Non-agriculture	0.71	0.46	2.42	1.12
Urban labor	0.62	0.59	2.98	2.81
Rural labor	0.54	0.62	2.45	8.98
Transfer payments	0.33	0.18	2.78	0.84
Urban diversified	0.68	0.70	2.42	0.86
Rural diversified	0.65	0.72	2.60	1.01
	US$2 per Day			
Stratum	Cambodia	Lao PDR	Thailand	Viet Nam
Agriculture	0.42	0.44	1.07	0.47
Non-agriculture	0.57	0.43	2.32	0.73
Urban labor	0.48	0.52	2.83	5.81
Rural labor	0.45	0.34	1.69	2.35
Transfer payments	0.21	0.14	0.63	0.14
Urban diversified	0.55	0.54	1.47	1.26
Rural diversified	0.49	0.55	1.01	0.77

Lao PDR = Lao People's Democratic Republic.

Source: Author's calculations.

Table 5 reports the share of national poverty in each of these strata, β_{rs}. This table shows that poverty is predominantly a rural phenomenon, with the bulk of the poor concentrated either in the agricultural (Lao PDR) or the rural diversified stratum (Thailand) or both (Cambodia and Viet Nam).

Table 5: Share of National Poverty by Stratum (%)

	US$1 per Day			
Stratum	Cambodia	Lao PDR	Thailand	Viet Nam
Agriculture	39.3	77.0	6.3	38.9
Non-agriculture	3.2	4.0	1.9	1.1
Urban labor	2.0	1.3	0.4	1.1
Rural labor	2.1	0.3	5.6	1.1
Transfer payments	1.1	0.8	11.4	10.0
Urban diversified	6.3	5.4	6.6	3.3
Rural diversified	46.1	11.2	67.8	44.4
Total	100.0	100.0	100.0	100.0
	US$2 per Day			
Stratum	Cambodia	Lao PDR	Thailand	Viet Nam
Agriculture	32.0	69.3	7.0	24.5
Non-agriculture	5.1	3.2	3.5	1.4
Urban labor	1.9	1.6	1.8	1.2
Rural labor	1.9	0.3	9.5	1.2
Transfer payments	0.6	0.3	8.3	2.7
Urban diversified	8.8	7.3	8.8	9.8
Rural diversified	49.8	18.0	61.0	59.3
Total	100.0	100.0	100.0	100.0

Lao PDR = Lao People's Democratic Republic.

Source: Author's calculations.

Table 6 reports the average expenditure share, at producer prices, on the 10 broad commodity aggregates in our consumer demand system, at the two poverty lines (US$1 per day and US$2 per day). Food clearly dominates the budgets of the poorest (US$1 per day) households in all four countries—but particularly for Cambodia and the Lao PDR. Therefore, the cost of living at the US$1 per day poverty line will be very sensitive to the price of foodstuffs. By the time income rises to the US$2 per day level, the share of crop products in total expenditure has declined by nearly half in Cambodia and Viet Nam, while at the same time, the share of total expenditure devoted to manufactures and services, including housing and education, has risen sharply.

Table 6: Average Budget Share at the Poverty Line

US$1 per Day				
Commodity	Cambodia	Lao PDR	Thailand	Viet Nam
Crops	45.7	40.2	28.7	31.4
Meat and fish	2.3	3.9	3.7	7.7
Other foods	28.5	31.5	19.6	22.9
Textiles and apparels	5.0	3.0	8.4	7.6
Utilities	0.5	1.5	2.2	3.6
Wholesale and retail trade	2.6	3.2	7.1	1.3
Manufactures	8.4	4.8	11.5	12.7
Transport and communication	1.3	4.0	10.0	3.3
Business services	0.6	0.2	1.0	2.5
Housing and education	5.1	7.7	7.9	7.0
Total	100.0	100.0	100.0	100.0
US$2 per Day				
Commodity	Cambodia	Lao PDR	Thailand	Viet Nam
Crops	23.1	33.0	17.1	16.6
Meat and fish	9.4	5.5	5.3	12.8
Other foods	22.4	32.6	14.4	16.9
Textiles and apparels	5.8	2.5	10.0	9.2
Utilities	2.0	2.1	3.1	6.0
Wholesale and retail trade	6.1	4.1	9.8	1.1
Manufactures	11.4	4.0	13.8	16.9
Transport and communication	5.3	5.8	14.2	5.5
Business services	1.1	0.1	1.6	4.6
Housing and education	13.5	10.3	10.7	10.3
Total	100.0	100.0	100.0	100.0

Lao PDR = Lao People's Democratic Republic.

Source: Author's calculations.

With this information in hand, we can evaluate the impact of land transport infrastructure projects in the GMS on poverty.

4. MODELING IMPROVED GMS INFRASTRUCTURE AND TRADE FACILITATION

The scenarios modeled in this study aim to provide insights into the impacts of selected infrastructure improvements in the GMS. Poor infrastructure can be a significant cost factor in economic activity. As shown by Henderson, Shalizi, and Venables (2001), transport costs in many developing regions of the world are far from negligible. For example, costs measured by the cost, insurance, and freight/free on board (CIF/FOB) ratio can be as high as 40% in landlocked countries. The crude measure of transport costs introduced earlier (Appendix 4) shows that these values can be significant in the GMS, for example in exports of crops, other foods, and textiles.

Road infrastructure improvements reduce transport costs through a number of channels. They reduce vehicle operating costs including maintenance and prolong the life of the asset. They reduce transport time, resulting in labor cost benefits. They make for better inventory

management and improvement in the overall productivity associated with transport as the same resource base provides more services (i.e., the same truck and driver make more deliveries). Economy-wide, better transport systems lead to economies of scale and different patterns of agglomeration; improved access to markets; network externalities; more efficient market clearing; and enhanced competition as a result of improved information flows (see, for example, Jensen 2007; Hulten, Bennathan, and Srinivasan 2005). Improved infrastructure connecting the GMS economies is also necessary for the realization of many of the benefits of trade facilitation efforts.

4.1   GMS Infrastructure Improvements

Since 2005, nine economic corridors have been proposed for the region and these are currently at varying stages of implementation (Figure 2). The goal in developing these economic corridors is to enhance regional linkages among neighboring countries in order to facilitate trade and develop logistics for better access to global markets. The development of economic corridors goes beyond improvements in physical infrastructure to include enhanced trade facilitation and institutional and regulatory linkages.

Figure 2: GMS Economic Corridors

Note: Further details and maps for each corridor are available at www.adb.org/GMS/Economic-Corridors.

Source: Asian Development Bank.

To date, evaluations of the benefits of economic corridor development in the GMS have tended to be qualitative. However, several attempts at more quantitative measures have been made. Fujimura and Edmonds (2008) estimated the impact of road infrastructure on trade and foreign direct investment (FDI) flows in the GMS. They found a positive relationship between trade in major goods (both exports and imports) but results for FDI were inconclusive. Menon and Warr (2006) examined the relationship between road improvement and poverty in the Lao PDR. They reported that reducing transport costs

through rural road improvements generates significant reductions in poverty incidence, though the type of road was shown to be a major factor in the results. Finally, ADB conducted three case studies covering border provinces in Cambodia, Lao PDR, and Viet Nam. The studies found that poverty incidence is higher in "less integrated areas" compared with "more connected areas." The benefits of integration included improved job opportunities, greater access to high quality goods and health facilities, and the acquisition of better farming techniques (Singh and Mitra 2006).

While these studies provide broad linkages between economic impacts and infrastructure investment, few have estimated the actual cost reductions associated with these investments. This is due to a lack of reliable, comprehensive data. Nonetheless, some attempts to estimate cost savings and other benefits have been made. For example, ADB produced estimates of reduced travel times and transportation costs expected from the full implementation of the East–West Economic Corridor Project.[13] The East–West Corridor is a road link of almost 1,500 kilometers; it will be the only direct land route between the Indian Ocean and the South China Sea, with great potential to accelerate economic development in the region. The route runs from Mawlamyine–Myaddy in Myanmar, through Mae Sot–Phitsanulok–Khon Kaen–Mukdahan in Thailand, though Savannakhet–Dansavanh in the Lao PDR, to Lao Bao–Hue–Dong Ha in Viet Nam. This route also intersects a number of north–south arterial links, facilitating improved transportation throughout the region. Full implementation of the route is expected to reduce transport costs by between 25% and 30% (ADB 2005b).

The Japan International Cooperation Agency (JICA) also prepared a report including estimates of cost savings from several cross-border GMS projects (JICA 2007). The report provides some data for the route from Hanoi to Bangkok via the Second Mekong International Bridge, which was completed in December 2006. Reductions in transit costs were estimated to be between 25% and 50% (JICA 2007). In addition, the Japanese External Trade Organization has developed an ASEAN Logistics Network Map. This map estimates costs and travel time in the region, based on surveys of Japanese companies.[14]

4.2 North–South Economic Corridor

The corridor that has progressed farthest in the GMS is the North–South Economic Corridor (NSEC), which links Kunming in Yunnan Province of the PRC to Bangkok and the Gulf of Thailand. This corridor is expected to provide access to the shipping routes of the South China Sea for output from Yunnan and Northern Thailand.

As shown in Figure 2, the NSEC is made up of three branches: Kunming–Bangkok; Kunming–Hanoi–Haiphong; and the Nanning–Hanoi transport corridors. The Kunming–Bangkok branch travels either through Myanmar, Lao PDR, or via the Mekong River. Some basic characteristics of the Kunming–Bangkok routes are shown in Table 7, with the shortest route in distance remaining via the Mekong River. In 2006, ADB undertook a study to estimate the impact of both the physical infrastructure developments along the NSEC and the effect of the Cross Border Transport Agreement (CBTA) that began to be implemented in December 2003. This agreement aims to streamline regulation and reduce institutional barriers to the movement of goods and people among the GMS countries. The CBTA is a multilateral instrument that covers all the relevant aspects of cross-border transport facilitation along certain agreed-to routes, including the NSEC. Provisions of the CBTA include one-stop customs inspection; improved cross-border movement of persons (i.e., visas for persons engaged in transport operations); transit traffic regimes, including exemptions from physical customs inspection, bond deposit, escort, and phytosanitary and

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[13] To be included in the forthcoming Completion Report of the Greater Mekong Subregion's East–West Transport Corridor Project.

[14] The map is still under development, so documentation is currently unavailable.

veterinary inspection; exchange of commercial traffic rights; and infrastructure, including road and bridge design standards, road signs, and signals.[15]

In undertaking analysis of the NSEC, Banomyong (2007) constructed a model based on a detailed logistical activity map of certain identified products moving along the corridor. The model describes the cost and time components of these movements and highlights delays at borders and other inspection points. Based on the characteristics described in Table 7, projections of cost and travel time were made assuming full implementation of the CBTA. Figure 3a and 3b illustrate some of these projections for the years 2006 and 2015.[16]

Table 7: Characteristics of Kunming–Bangkok Routes

Route	Logistics Infrastructure	Route Choice (distance in km)[a]		
		via Myanmar (R3W)	via Mekong River	via Lao PDR (R3E)
Bangkok–Chiang Rai	4-lane highway	830	830	830
Chiang Rai–Mai Sai	4-lane highway	60		
Chiang Rai–Chiang Saen	2-lane highway		60	
Chiang Rai–Chiang Khong	2-lane highway			110
Mai Sai–Mengla/Daluo	2-lane highway	253		
Chiang Saen–Jinghong	Mekong River and Port		360	
Chiang Khong–Boten/Mohan	2-lane highway			228
Mengla/Daluo–Kunming	6-, 4-, and 2-lane highway	674		
Jinghong–Kunming	6- and 4-lane highway		534	
Boten/Mohan–Kunming	6-, 4-, and 2- lane highway			688
		1,817	1,784	1,856

Lao PDR = Lao People's Democratic Republic; R3W = Route No. 3 West; R3E = Route No. 3 East.

[a] Distances approximated in 2007 assuming completion of all ongoing and planned infrastructure investment projects in 2008.

Source: Banomyong (2007).

As shown in Table 8, the estimated cost reductions across all three routes for the Bangkok–Kunming corridor are substantial. Via the Route No. 3 West (R3W), costs per ton are reduced by 26.5% between 2000 and 2006, and by almost 43.0% between 2006 and 2015. Transit times for the R3W are expected to drop almost 35% between 2006 and 2015. Via the Lao PDR route, reductions in costs and transit time are even greater, with estimated reductions of 30% and 35% between 2000 and 2006. By 2015, costs on this Lao PDR route should fall by a further 46% and transit times by 41%. For the route via the Mekong, reductions in costs are even higher, at 33% between 2000 and 2006, with a further 61% by 2015.

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[15] For a complete list of routes and provisions of the CBTA, see ADB (2005a).

[16] The 2015 projections are based on the para rubber industry and are thus illustrative of the kinds of savings to be expected along the routes. For details of the measurements, see Banomyong (2007).

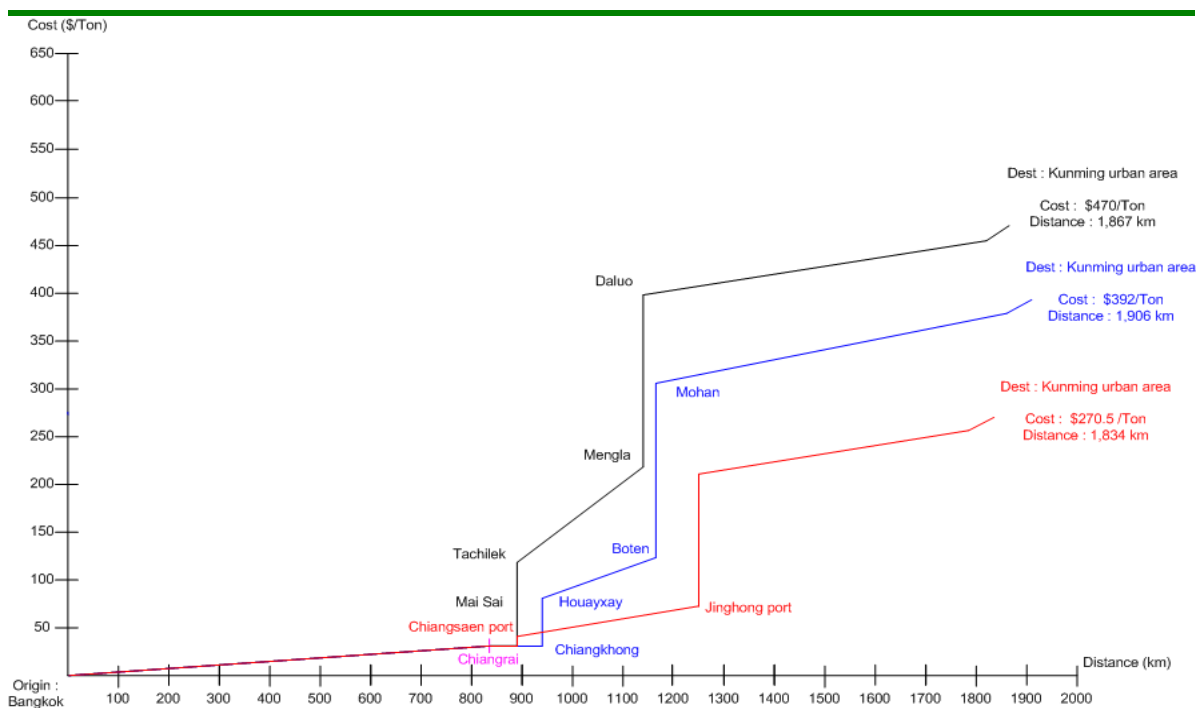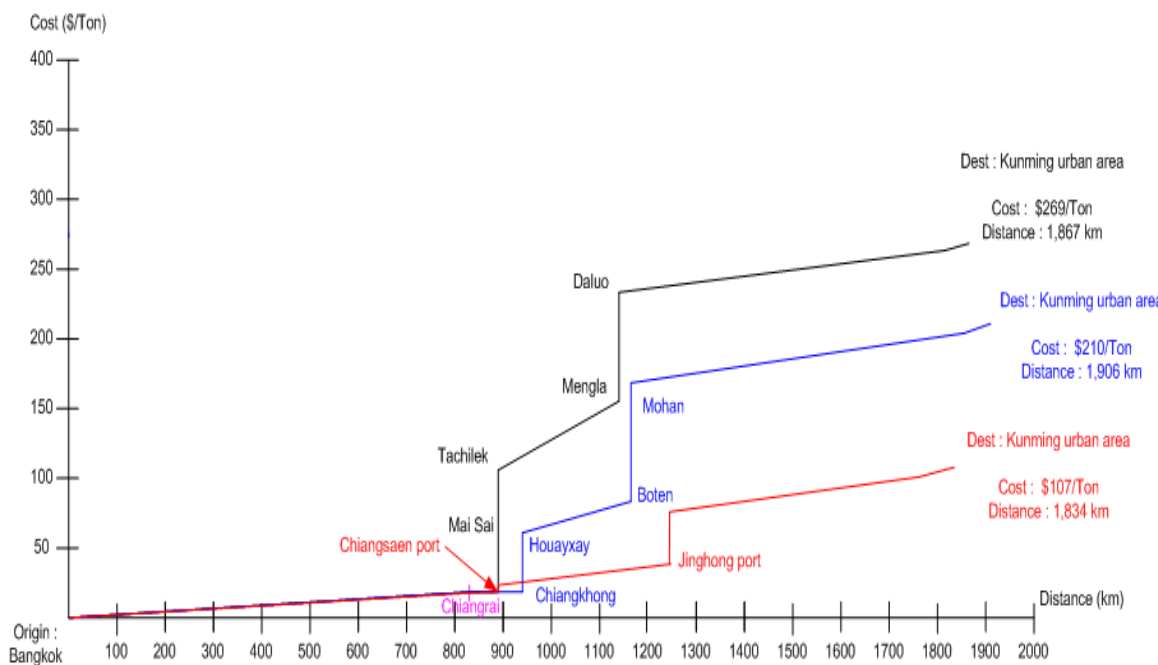**Figure 3a: Bangkok–Kunming Costs vs. Distance, 2006 (US$)**

Figure 3b: Bangkok–Kunming Costs vs. Distance, 2015 (US$)

Source: Banomyong (2007).

Table 8: Trends on the Bangkok–Kunming Corridor

Bangkok–Kunming	US$ per Ton	% Change	Transit Time (hours)	% Change
R3W (via Myanmar)				
• 2000				
• 2006	639		77	
• 2015	470	26.5	46	40.3
	269	42.8	30	34.8
R3E (via Lao PDR)				
• 2000	563		78	
• 2006	392	30.4	51	34.6
• 2015	210	46.4	30	41.2
Via Mekong				
• 2000	406		128	
• 2006	271	33.3	88	32.0
• 2015	107	60.5	70	54.3

Lao PDR = Lao People's Democratic Republic; R3W = Route No. 3 West; R3E = Route No. 3 East.

Source: Banomyong (2007) and authors' calculations.

4.3 Scenarios Modeled

While the importance of transport infrastructure is clear, measuring the impact of changes made to it is no simple task. Modeling infrastructure improvements is fraught with difficulty, going beyond the basic problem of obtaining a satisfactory measure of infrastructure services. Physical proxies may be relatively bad proxies for the services they are meant to capture. For example, measuring the impact of improved pavement capacity does not necessarily capture the changes in the economic value of the goods transported along this pavement. Measures of public or private investment spending also have difficulty capturing service flows. In developing countries, the problem is even more acute as official costs of investment are often disconnected from their effective value. In an effort to rise above these challenges, modelers have applied a variety of proxies to attempt to capture the key impacts of transport and infrastructure services. Traditional measures use simple proxies such as distance, ad valorem shares of trade volumes, or real freight expenditures such as vehicle operating costs. Indeed, Straub (2008) points out that simple time and distance measures do relatively well in cross-section settings.

In the current study, to model the gains from physical investment in transport infrastructure, we reduced transport margin costs. This approach captures reductions in real freight expenditures in the same vein as Menon and Warr (2006). Applying a reduction to the land transport margin has the benefit of impacting the variable most relevant to the question at hand: how do improvements in road transport affect economic activity? However, as alluded to above, the measurement of this variable is problematic. First, in GTAP, these transport margins apply to traded goods only and are based on the ratio of CIF/FOB prices rather than the actual cost of transport. Using CIF/FOB ratios means these measures only account for inter-country trade and do not allow for intra-country trade. Using the land transport margin as a proxy for road improvements in the GMS has another difficulty. It does not allow for the specification of any particular route or region within a country. That is, there is no ability to measure the spatial dimension. Finally, the land transport value reported in the GTAP database comprises road, rail, and pipeline. Singling out roads, let alone a particular road, is all but impossible.

Our focus is on exploring the region-wide impacts of infrastructure improvement, based on estimated cost reductions along those GMS routes where implementation is relatively advanced. We include cross-border physical road infrastructure and trade facilitation measures that will lower the costs of transporting goods between GMS countries. Improvements in both transport infrastructure and trade facilitation can bring substantial gains to the region. Some estimates suggest that indirect costs from time delays can have a

greater impact than direct costs on trade volumes (OECD 2003). As discussed above, we can adjust the direct costs of transport through the international transport margins. Within the model, however, it is also possible to capture the impacts on trade costs from improvements in trade facilitation through the CBTA. Both aspects are captured here in our "medium-run" scenario, which examines the impact of reducing transport costs and improving trade facilitation in the GMS.

The first component of this scenario attempts to capture improvements in the physical connectivity associated with the GMS Transport Strategy. Estimates of the cost savings through reduced vehicle operating cost, improved efficiency of trucks and drivers, and other cost savings are proxied by a reduction in the international land transport costs. Based on estimates of land transport cost reductions resulting from the NSEC as presented above (see also studies reviewed in Stone and Strutt 2010), we applied a reduction in land transport costs of 45%.[17] We endeavored to capture the broader linkages of the transport corridor network by taking account of the other GMS economic corridors that intersect with the North–South Corridor, helping to improve land transportation linkages within the entire GMS. Therefore, we modeled the impact of a reduction in land transportation costs for all intra-GMS trade. For the PRC, we assumed that the 45% reduction in land transport costs related to the GMS would be equivalent to a 25% reduction in the PRC's transport margins. While Yunnan and Guangxi make up a relatively small part of the overall PRC economy, much of the trade with the GMS for goods transported by land is likely to enter and exit the PRC through these provinces. However, given the relative uncertainty of the overall reduction of transportation costs with the PRC, we take some care when analyzing the results to separate out these impacts.

The second component of this scenario encompasses the benefits of implementation of the CBTA. Through improved border crossing, harmonization of registration processes, and other bureaucratic matters, trade facilitation should improve throughout the GMS. Many studies have found that the ensuing price reductions have the potential to surpass the benefits of tariff reductions over time. To include the effects of an improvement in trade facilitation measures, we implemented an approach introduced in Hertel, Walmsley, and Itakura (2001) and also used by Minor and Tsigas (2008). The approach allows for a region-specific shift in the Armington demand function, effectively lowering the foreign market price. Based on the studies of expected time savings if the CBTA were to achieve improved facilitation to world standards, we assumed a reduction in effective import prices of 25%. For the reasons discussed above, we need to differentiate the shock for the PRC; we assumed a 5% cost reduction between the GMS and the PRC as a whole.

5. RESULTS AND DISCUSSION

In this section, we present results of the simulation described above, followed by detailed analysis of the poverty implications.

5.1 Impacts of Transport Improvements on the GMS

The results for this scenario are reported in Table 9. The table shows projected changes for each GMS economy at the aggregate level, including real output, exports, and economic welfare. These results suggest that changes in real GDP are highest for those countries with relatively large transport costs—namely Cambodia and the Lao PDR. The projected changes in real GDP for the region total over US$5,500 million (over US$4,300 million excluding gains accruing to the PRC). All of the GMS economies experience increases in GDP of

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[17] These transportation cost reductions are proxied by productivity improvements in the transportation margin sector covering land transportation.

between 1.1% and 8.3%, with the highest percentage increase in Cambodia, followed by Lao PDR, Myanmar, Viet Nam, and Thailand. Since only a relatively small part of the PRC is included in the GMS, the gains for PRC, in percentage terms, are relatively small. As shown in the third row of Table 9, the exclusion of the impact of improved infrastructure and trade facilitation with the PRC affects the GMS economies to varying extents. For Viet Nam and Thailand, the impact of improved transportation for trade with the PRC appears to be an important driver of the GDP results; Viet Nam's GDP gains are significantly lower in the absence of transportation and trade facilitation cost reductions with the PRC and Thailand's gains are eroded by over 36%. Other GMS economies appear much less reliant on gains from improved transportation for trade with the PRC. For Myanmar, the impact on GDP would be a reduction of less than 13%, about 7% for Cambodia, and less than 3% for the Lao PDR.

Table 9: Aggregate Impacts of Reduced Costs of
Road Transport and Trade Facilitation

	Cambodia	Lao PDR	Myanmar	Thailand	Viet Nam	PRC
GDP (US$ mn)	403.9	173.4	363.2	1,822.3	1,539.2	1,201.8
GDP (%)	8.3	7.1	4.7	1.1	3.6	0.1
GDP (% excluding PRC)	7.7	6.9	4.1	0.7	2.4	0.0
Exports (US$ mn)	226.6	−28.1	50.5	3,356.8	1,201.0	1,787.1
Exports (%)	5.3	−4.3	1.7	2.8	3.7	0.3
EV (US$ mn)	480.6	261.3	618.6	2,955.5	2,157.9	1,441.0
EV (US$ mn excluding PRC)	460.4	259.5	557.6	1,734.9	1,390.7	−206.5
Contribution to welfare (%)						
Allocative efficiency	12.6	4.8	12.5	16.8	5.0	6.0
Improved terms of trade	10.5	22.6	37.3	39.9	21.8	15.7
Improved transport	0.1	3.6	3.9	2.8	5.7	2.2
Improved trade facilitation	71.8	62.7	47.2	45.0	66.7	77.4

EV = equivalent variation; GDP = gross domestic product; Lao PDR = Lao People's Democratic Republic; PRC = People's Republic of China.

For all GMS economies with improved infrastructure, the change in economic welfare, as measured using equivalent variation in income, is positive. The total change in welfare for the region is US$7,915 million, however, this would be reduced if there were no reduction of costs between the PRC and other GMS countries (see row 7 in Table 9). For all GMS economies, allocative efficiency improves with better transportation facilitating the movement of resources into more productive activities. This impact is particularly strong for Thailand, contributing almost 17% of the increase in welfare. Terms of trade improvements are experienced by all GMS economies, again leading to increased welfare. This impact is primarily due to an increase in the regional export prices, while regions outside the GMS tend to experience a decline in their regional export prices. This relative change, however, does not dampen the export performance of the region, with the exception of the Lao PDR, which experiences a small decline in total exports. However, as will be discussed below, the Lao PDR's intra-regional export growth is over 80%, implying large potential gains as the GMS market grows.

The direct contribution to economic welfare of improved land transportation productivity is shown in Table 9 to be small but significant, with the exception of Cambodia. The final row of Table 9 reports the contribution from improved trade facilitation and this contributes the bulk of the welfare gains in the region. These gains are made by effectively lowering import prices through reductions associated with improvements in the institutional and regulatory "software" accompanying the transportation "hardware." This result illustrates the great potential impact of measures that facilitate the efficient movement of goods across borders once the physical infrastructure is in place.

While Table 9 indicates that total exports are expected to increase for GMS countries (except for the Lao PDR), the impact on intra-GMS exports is perhaps of even greater interest. Table 10 presents details of changes in the value of intra-regional export flows. All of the economies increase exports within the region between almost US$150 million and almost US$10,000 million. For all of the countries, with the exception of Cambodia, the largest increases in bilateral exports are to Thailand. This underscores the importance of lower land transportation and trade facilitation costs with Thailand for most of the GMS countries. In the case of Cambodia, it is exports to Viet Nam that are expected to increase by the most, at over US$272 million. For Thailand, increases in exports are spread between all GMS countries, with the largest dollar increases in exports to Viet Nam and the PRC.

Table 10: Change in the Value of Intra-GMS Exports (US$ Million)

Into: From:	Cambodia	Lao PDR	Myanmar	Thailand	Viet Nam	PRC	Total
Cambodia		1.3	0.4	207.1	272.1	3.8	484.7
Lao PDR	0.1		0.0	123.4	28.9	−3.2	149.2
Myanmar	0.1	0.0		486.2	16.2	2.9	505.5
Thailand	552.1	224.9	818.8		4,174.9	4,222.1	9,992.8
Viet Nam	160.6	15.9	14.9	2,715.5		646.5	3,553.5
PRC	−65.2	−39.4	−71.9	2,477.4	1,020.8		3,321.6

Lao PDR = Lao People's Democratic Republic; PRC = People's Republic of China.

5.2 Impacts on Poverty

Turning now to the poverty impacts of the scenario modeled, we begin with the poverty drivers reported in Table 11. These real earnings changes suggest that, in nearly all cases, factor earnings are rising relative to the cost of living at the poverty line. While the total nominal factor earnings for both groups of poor (US$1 per day and US$2 per day) are the same, their cost of living differs, so the entries in the top section of Table 11 (US$1 per day) differ from those in the bottom section (US$2 per day) by a common factor (the difference in cost of living at the different poverty lines). From Table 11, we see that the largest earnings increases are for the non-agricultural factors—particularly skilled labor. This may be driven by the increase in output in the electronics and other manufacturing sectors experienced by these economies. Land generally experiences a most modest rise in real earnings, and real land rents actually decline in the case of Thailand.

Table 11: Deflated Endowment Price Changes, by Country (%)

US1$ per Day				
Endowment	Cambodia	Lao PDR	Thailand	Viet Nam
Ag. land	7.79	6.71	–0.60	0.49
Ag. labor (unskilled)	7.51	7.52	0.63	3.49
Ag. labor (skilled)	8.09	9.22	0.86	4.16
Non-ag. labor (unskilled)	7.20	9.06	2.11	7.11
Non-ag. labor (skilled)	8.43	11.91	2.33	7.98
Wage labor (unskilled)	7.26	8.40	1.87	6.60
Wage labor (skilled)	8.42	11.86	2.33	7.97
Agricultural capital	7.75	7.63	0.83	3.81
Non-ag. capital	7.74	8.69	2.28	7.33
Transfer payments	10.46	10.53	2.83	6.09
US$ per Day				
Endowment	Cambodia	Lao PDR	Thailand	Viet Nam
Ag. land	7.94	7.07	–0.72	0.37
Ag. labor (unskilled)	7.67	7.89	0.51	3.37
Ag. labor (skilled)	8.25	9.60	0.74	4.03
Non-ag. labor (unskilled)	7.35	9.43	1.98	6.98
Non-ag. labor (skilled)	8.58	12.29	2.21	7.85
Wage labor (unskilled)	7.42	8.77	1.75	6.47
Wage labor (skilled)	8.58	12.24	2.21	7.84
Agricultural capital	7.91	8.00	0.70	3.69
Non-ag. capital	7.89	9.07	2.16	7.21
Transfer payments	10.62	10.91	2.71	5.96

Lao PDR = Lao People's Democratic Republic.

Applying the stratum-specific poverty elasticities to the real earnings changes in Table 11 gives the percentage changes in poverty headcount by stratum in Table 12. The changes are relatively even across many strata within each country. However, the small change in poverty headcount in households that depend on payment transfers in Cambodia and the Lao PDR is notable. This follows from relatively low poverty elasticities, suggesting a low density of the transfer-dependent households around the poverty line in those countries. Also notable is the extremely large reduction in poverty for the wage labor households in Viet Nam, where the poverty elasticity is very large.

Table 12: Change in Poverty Headcount, by Stratum and Country (%)

| | US$1 per Day | | | |
Stratum	Cambodia	Lao PDR	Thailand	Viet Nam
Agriculture	–4.56	–4.36	–1.31	–1.59
Non-agriculture	–4.88	–4.23	–4.97	–7.44
Urban labor	–4.58	–5.53	–5.41	–16.46
Rural labor	–3.99	–6.16	–4.46	–44.91
Transfer payments	–3.24	–1.77	–7.43	–4.82
Urban diversified	–5.05	–6.22	–4.23	–4.19
Rural diversified	–4.72	–6.22	–4.63	–6.27
Total	–4.65	–4.66	–4.71	–4.79

| | US$2 per Day | | | |
Stratum	Cambodia	Lao PDR	Thailand	Viet Nam
Agriculture	–3.11	–3.46	–0.55	–1.19
Non-agriculture	–4.14	–3.98	–4.49	–4.83
Urban labor	–3.58	–5.18	–4.84	–32.97
Rural labor	–3.31	–3.54	–2.92	–13.99
Transfer payments	–2.08	–1.39	–1.66	–0.8
Urban diversified	–4.19	–4.95	–2.35	–7.02
Rural diversified	–3.72	–4.79	–1.65	–4.35
Total	–3.57	–3.84	–1.91	–4.19

Lao PDR = Lao People's Democratic Republic.

Table 13 converts these percentage changes into number of individuals. Here, we see that for the GMS-4 total (Cambodia, Lao PDR, Thailand, and Viet Nam combined), more than 400,000 people are moved out of extreme poverty, with another 1.75 million being lifted above the US$2 per day poverty line. The largest share (about half) of the extreme poverty alleviation is in Cambodia. This reflects Cambodia's large share in US$1 per day poverty in the region. On the other hand, Viet Nam dominates the US$2 per day poverty reduction in the region, as it dominates the poverty headcount at this higher level of income. At the stratum level, across the GMS-4, the bulk of the poverty reduction comes in the rural areas, with rural diversified households accounting for around one half of the poverty reduction at both poverty levels. This provides strong evidence that road improvements and improved connectivity benefit the rural poor in the region.

**Table 13: Change in Poverty Headcount, by Stratum and Country
(Number of Individuals)**

			US$1 per Day		
Stratum	Cambodia	Lao PDR	Thailand	Viet Nam	GMS-4
Agriculture	83,504	54,483	936	7,720	146,643
Non-agriculture	7,289	2,760	1,087	1,035	12,171
Urban labor	4,272	1,121	230	2,280	7,903
Rural labor	3,905	303	2,879	6,219	13,306
Transfer payments	1,658	236	9,670	6,010	17,574
Urban diversified	14,858	5,409	3,206	1,741	25,214
Rural diversified	101,467	11,323	35,994	34,762	183,546
Total	216,953	75,635	54,002	59,767	406,357

			US$2 per Day		
Stratum	Cambodia	Lao PDR	Thailand	Viet Nam	GMS-4
Agriculture	106,708	102,610	6,263	62,333	277,914
Non-agriculture	22,648	5,472	25,440	14,039	67,599
Urban labor	7,291	3,640	14,010	82,203	107,144
Rural labor	6,747	409	44,533	34,885	86,574
Transfer payments	1,333	190	22,142	4,560	28,225
Urban diversified	39,558	15,507	33,258	146,793	235,116
Rural diversified	198,348	36,923	161,429	549,520	946,220
Total	382,633	164,751	307,075	894,333	1,748,792

5.3 Mitigating Factors

We should emphasize that our results report the anticipated gains, given the set of assumptions made. If the necessary policy and institutional environment that will allow GMS economies to adapt and exploit new opportunities is absent, these gains are far from assured.

The gains from improvements in transport and trade facilitation presented above must also be tempered by the potential negative impacts of enhanced transport networks in the region. For example, as transit countries, the Lao PDR and Cambodia, having fewer resources and lower economic competitiveness, may suffer from worsening traffic safety. Traffic accidents are a concern across the developing world. An ADB (2005b) study provided estimates of annual economic loss from road accidents for GMS countries to be over US$4.7 billion or over 2% of annual GDP. This value is substantiated by EU estimates that road accidents cost approximately 1% to 3% of GDP in India (ERTICO 2008). Lost time, damaged cargo and vehicles, lack of insurance, injuries, and even death all add to the high costs of traffic accidents. There are also concerns about deterioration of the natural environment as a result of growing flows of transit cargo and there is a concern among residents that only foreign multinational companies will reap the benefits of cross-border trade expansion (JICA 2007).

Adverse human health impacts may also accompany improved infrastructure. For example, the spread of HIV and AIDS has been known to closely follow the progress of economic integration in the GMS. For instance, the number of HIV-positive persons and AIDS patients was reported to rise sharply in Savannakhet while the Second Mekong Bridge was under construction (JICA 2007).

Furthermore, concern exists that improved infrastructure may accentuate problems of human trafficking and illegal trade in narcotics. These issues are deeply rooted in the

problem of poverty. According to a report on villages in the Lao PDR, those who wanted to work outside their own countries were often victimized (ADB 2006), with a third given false information about their earnings or forced to work in a job different from the initial promise (often prostitution in the case of women).

This brief discussion of possible adverse impacts is far from complete, and further case studies that explore these issues and more (including environmental damage) are needed. However, potential negative impacts need to be viewed in the context of further positive effects that may occur within the region. The increased exposure to new businesses that comes with greater connectivity increases the opportunities for improved technological adaptation. Indeed, it has been shown that improving connectivity has been shown to raise productivity and land values for poor farmers (Iimi and Smith 2007). Evidence has shown that improved transport has increased school attendance (Levy 2004), increased maternal and natal care (Ishimori 2003), improved working conditions and wage levels (Singh and Mitra 2006), and increased levels of FDI (Luanglatbandith 2007). None of these dynamic, positive effects have been explicitly considered in this study. Thus, the net outcome of the dynamic interaction between the negative and the positive potential impacts is very difficult to assess.

6. CONCLUDING REMARKS AND FUTURE DIRECTIONS

This paper undertook a general equilibrium assessment of the impacts of infrastructure development across the GMS. Supporting databases developed for this study facilitated the assessment of outcomes across the whole GMS, including poverty impacts, in a way that has not previously been possible. Our findings suggest that strong gains to the GMS countries should result from infrastructure development and trade facilitation, with particularly positive impacts on incomes and poverty levels in the relatively poor countries of Cambodia and the Lao PDR. While we found particularly significant gains from trade facilitation, it must be remembered that these gains will not be possible without first improving physical connectivity to enable efficient road transportation between countries in the region.

We are mindful of the need for a supportive institutional and domestic policy environment that allows markets to develop and take advantage of the new opportunities offered by improved infrastructure and trade facilitation measures. We also acknowledge that serious data issues remain in the GMS, including matching domestic data to international frameworks and the problem of unrecorded border trade. Informal trade appears to account for a significant share of cross-border trade in the GMS, perhaps on the order of 20% to 30% of trade (Athukorala 2007). There are also a number of limitations in the types of simulations we are able to undertake, particularly because estimates of benefits such as reduced travel costs are sparse and there are challenges in translating these into modeling scenarios that will appropriately capture the impact of the infrastructure development in the GMS. We must also note that there are difficulties in trying to separate the benefits of cross-border transport infrastructure development from domestic infrastructure development. Despite these and other limitations, we hope that the current study offers useful insights into some of the socioeconomic impacts of transport infrastructure, a key development issue for the GMS.

APPENDIX 1: REGIONAL AGGREGATION

Region	Detailed Description
Cambodia	Cambodia
Lao PDR	Lao People's Democratic Republic
Myanmar	Myanmar
Thailand	Thailand
Viet Nam	Viet Nam
PRC	People's Republic of China
Other ASEAN	Indonesia, Malaysia, Philippines, Singapore
High Income Asian	Japan; Republic of Korea; Hong Kong, China; and Taipei,China
South Asia	Bangladesh, India, Pakistan, Sri Lanka, Rest of South Asia
ANZ	Australia and New Zealand
Europe	European Union 25, European Free Trade Association, Rest of Europe
NAFTA	Canada, United States, Mexico
CAREC	Central Asia Regional Economic Cooperation
ROW	Rest of the World

APPENDIX 2: COMMODITY AGGREGATION

Aggregated Sectors	Modeled Sectors	Original GTAP Sectors
Crops	Paddy rice	pdr
	Vegetables and fruit	v_f
	Other crops	wht gro osd c_b pfb ocr
	Forestry	frs
Meat and fish	Livestock	ctl oap rmk wol
	Fishery	fsh
Other foods	Processed animal products	cmt omt mil
	Processed rice	pcr
	Processed foods	vol sgr ofd b_t
Textiles, apparels, leather	Textiles	tex
	Wearing apparel	wap
	Leather products	lea
Manufactures	Petroleum	oil p_c
	Other minerals	omn
	Wood and paper products	lum ppp
	Electronic equip. and machin.	ele ome
	Other manufactures	crp nmm i_s nfm fmp mvh otn omf
Wholesale and retail trade	Wholesale-Retail Trade	trd
Utilities	Utilities	coa gas ely gdt wtr
	Construction	cns
Business services	Business Services	ofi isr obs
Housing and education	Housing, Health and Educ.	ros osg dwe
Transport and communication	Communications	cmn
	Other transport	otp
	Water transport	wtp
	Air transport	atp

GTAP = Global Trade Analysis Project.

APPENDIX 3: GMS EXPORTS (US$ MILLION)

	Crops	Meat and Fish	Other Foods	Text., Apparel and Leather	Manufs.	Whsale and Retail	Utilities	Business Services	Housing and Educ.	Transport and Commun.	Total
Cambodia											
Lao PDR	0.0	0.0	0.0	0.0	0.5	0.0	0.0	0.0	0.0	0.0	0.6
Myanmar	0.0	0.0	0.2	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.4
Thailand	3.8	2.4	1.1	0.5	37.5	0.6	0.5	0.1	1.5	2.3	50.4
Viet Nam	16.4	0.2	1.0	2.0	103.6	0.1	0.0	0.0	0.4	0.7	124.4
PRC	0.3	1.3	1.2	7.9	16.5	4.0	0.3	0.6	6.6	9.1	48.0
World	33.8	17.7	83.8	3,099.1	311.3	67.1	21.1	19.1	216.7	358.7	4,228.3
GMSC (% world trade)	*60.9*	*22.1*	*4.2*	*0.3*	*50.8*	*7.1*	*4.0*	*3.9*	*3.9*	*3.4*	*5.3*
Lao PDR											
Cambodia	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.3
Myanmar	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Thailand	13.1	2.0	0.2	1.4	81.6	0.1	2.0	0.0	0.4	0.5	101.2
Viet Nam	21.5	2.1	2.0	1.1	41.1	0.0	0.0	0.0	0.2	0.1	68.2
PRC	6.0	0.0	0.5	0.1	2.5	0.2	0.1	0.1	1.5	2.1	13.0
World total	62.0	4.3	16.7	181.7	185.4	6.8	8.9	3.1	97.2	75.0	641.1
GMSC (% world trade)	*65.4*	*95.7*	*16.2*	*1.5*	*67.7*	*4.1*	*22.9*	*2.9*	*2.1*	*3.7*	*28.5*
Myanmar											
Cambodia	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2
Lao PDR	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Thailand	74.2	59.3	11.1	0.3	97.2	0.5	771.0	0.3	0.2	0.3	1,014.3
Viet Nam	7.3	0.8	3.0	0.5	6.6	0.1	0.0	0.1	0.1	0.1	18.6
PRC	79.9	0.5	5.9	0.7	57.3	3.6	0.1	0.8	0.6	0.5	149.9
World total	703.6	76.0	219.7	610.6	341.6	39.2	772.9	45.9	41.4	74.2	2,925.1
GMSC (% world trade)	*23.0*	*79.6*	*9.1*	*0.3*	*47.2*	*10.7*	*99.8*	*2.4*	*2.1*	*1.3*	*40.4*

	Crops	Meat and Fish	Other Foods	Text., Apparel and Leather	Manufs.	Whsale and Retail	Utilities	Business Services	Housing and Educ.	Transport and Commun.	Total
Thailand											
Cambodia	0.9	5.6	106.2	67.5	377.5	0.6	3.9	0.1	0.1	1.2	563.5
Lao PDR	6.7	1.0	74.3	58.4	313.6	0.0	0.0	0.0	0.1	0.1	454.2
Myanmar	3.7	0.3	153.3	53.8	404.8	0.1	0.0	1.1	0.1	0.3	617.5
Viet Nam	21.7	2.4	91.4	177.0	1,712.6	4.0	1.2	6.5	2.7	15.1	2,034.5
PRC	476.0	15.1	506.1	575.7	12,401.6	138.0	9.3	57.0	51.3	207.0	14,437.1
World total	1,814.1	259.0	11,886.0	9,587.2	80,386.6	2,014.8	290.4	3,521.3	1,660.3	8,045.5	119,465.2
GMSC (% world trade)	*28.1*	*9.5*	*7.8*	*9.7*	*18.9*	*7.1*	*5.0*	*1.8*	*3.3*	*2.8*	*15.2*
Viet Nam											
Cambodia	5.0	2.5	39.5	27.5	121.2	0.1	1.5	0.1	0.1	0.2	197.6
Lao PDR	2.3	0.1	2.4	20.3	25.7	0.0	0.0	0.0	0.1	0.0	50.8
Myanmar	0.0	0.0	0.5	1.8	11.3	0.0	0.0	0.2	0.1	0.0	13.9
Thailand	12.5	9.0	31.6	22.3	601.6	2.0	66.8	7.7	2.7	4.0	760.1
PRC	111.4	5.3	103.7	108.4	2,419.8	16.9	176.0	24.3	11.9	10.8	2,988.6
World total	1,651.5	274.7	3,626.6	10,942.2	12,470.8	157.3	551.7	1,124.0	655.0	742.7	32,196.5
GMSC (% world trade)	*7.9*	*6.1*	*4.9*	*1.6*	*25.5*	*12.0*	*44.3*	*2.9*	*2.3*	*2.0*	*12.5*
PRC											
Cambodia	3.2	0.1	27.4	368.9	121.1	7.6	2.5	0.4	0.7	1.6	533.4
Lao PDR	0.5	0.0	0.5	9.6	62.3	0.0	0.1	0.0	0.2	0.1	73.4
Myanmar	13.5	0.4	29.5	149.4	627.8	0.1	0.0	1.9	0.4	0.5	823.6
Thailand	80.4	27.3	176.7	673.9	6,128.4	206.9	33.7	43.1	56.6	87.8	7,515.0
Viet Nam	184.9	12.9	94.0	1,058.3	3,746.1	39.9	7.0	13.7	12.5	20.9	5,190.1
World total	5,661.5	2,960.9	16,344.6	134,033.5	472,484.8	15,614.3	5,706.5	7,079.2	7,689.4	13,191.0	680,765.6
GMSC (% world trade)	*5.0*	*1.4*	*2.0*	*1.7*	*2.3*	*1.6*	*0.8*	*0.8*	*0.9*	*0.8*	*2.1*

GMS = Greater Mekong Subregion; GMSC = GMS including PRC; Lao PDR = Lao People's Democratic Republic; PRC = People's Republic of China.

Source: GTAP Version 7, C2 database, October 2008.

APPENDIX 4: RATIO OF BILATERAL LAND TRANSPORT MARGINS TO EXPORT VALUE (%)[A]

	Crops	Meat and Fish	Other Foods	Textiles, Apparel, and Leather	Manufs.	Utilities	Total
Cambodia							
Lao PDR	n/a	7.02	2.66	9.32	0.70	n/a	0.91
Myanmar	n/a	n/a	0.25	0.02	0.01	n/a	0.13
Thailand	13.67	14.02	6.25	5.45	30.03	n/a	24.24
Viet Nam	38.16	12.97	28.88	8.61	12.10	n/a	15.50
PRC	0.01	0.07	0.13	0.04	0.17	n/a	0.07
World total	21.45	2.83	1.31	0.78	7.95	n/a	1.37
Lao PDR							
Cambodia	n/a	n/a	0.03	n/a	0.16	n/a	0.14
Myanmar	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Thailand	16.05	4.55	9.63	8.00	16.71	28.70	16.33
Viet Nam	8.63	4.22	12.99	6.11	10.34	n/a	9.57
PRC	9.70	n/a	3.00	3.10	11.27	n/a	6.75
World total	7.98	4.30	2.12	1.50	10.89	6.36	4.52
Myanmar							
Cambodia	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Lao PDR	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Thailand	15.04	19.36	7.26	6.45	6.24	4.68	6.47
Viet Nam	1.14	1.01	3.32	1.44	0.72	n/a	1.33
PRC	8.53	7.87	4.62	15.60	9.37	8.05	8.42
World total	3.82	15.32	1.77	1.88	5.83	4.67	3.76
Thailand							
Cambodia	0.07	0.10	0.11	0.06	0.09	0.14	0.09
Lao PDR	6.01	3.87	7.82	3.74	4.82	0.04	5.19
Myanmar	10.17	5.68	8.30	5.08	5.56	n/a	6.21
Viet Nam	2.72	3.51	4.11	1.68	1.55	0.03	1.67
PRC	0.89	0.05	0.24	0.04	0.03	n/a	0.06
World total	9.19	2.62	3.75	1.00	0.91	n/a	1.21
Viet Nam							
Cambodia	0.85	0.04	0.16	0.07	0.06	n/a	0.10
Lao PDR	14.58	2.78	5.62	3.05	2.56	0.88	3.44
Myanmar	n/a	n/a	0.06	0.02	0.01	n/a	0.01
Thailand	9.27	2.84	4.58	3.26	1.15	1.12	1.48
PRC	22.27	5.91	21.24	8.18	2.00	10.20	4.10
World total	3.88	2.19	4.04	1.23	1.70	3.58	1.81
PRC							
Cambodia	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Lao PDR	n/a	n/a	4.42	3.59	2.13	n/a	2.46
Myanmar	20.46	3.11	6.26	5.50	3.58	0.10	4.29
Thailand	18.58	3.59	6.64	3.01	1.60	0.12	1.94
Viet Nam	21.63	7.14	8.68	7.40	7.98	0.06	8.22
World total	6.39	2.08	2.68	1.45	1.02	0.29	1.12

n/a = not applicable.
Lao PDR = Lao People's Democratic Republic; PRC = People's Republic of China.
[a] Service sectors do not have land transport margins therefore are not included in this table (however the value of service trade is included in the total column).
Source: GTAP Version 7, C2 database, October 2008.

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