Regional Economic Impacts of Large Projects: A General Equilibrium Application to Cross-Border Infrastructure

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A general equilibrium framework is used to study the regional economic effects of infrastructure improvements designed to reduce the costs of inter-regional trade. The results suggest that in the short run the kind of transport cost reductions consistent with improvement of inter-regional transport facilities will produce a modest increase in inter-regional trade volumes in both directions. This coincides with a small increase in real consumption in both regions and correspondingly small reductions in poverty incidence. Over a longer period, the benefits to both regions, including reductions in poverty incidence, are much larger, as investors respond to the changed structure of incentives with new capital investments, and as workers move to regions of greater return to their labor. Because these benefits are significant in both regions, the results do not confirm the common presumption that the benefits from cross-border infrastructure projects occur only, or overwhelmingly, in the richer region.

I. INTRODUCTION

Estimating the potential benefits of large-scale public investment projects often poses a practical problem for decision makers. The full economic impacts of such projects can be highly complex; and if these impacts are incorrectly estimated, costly mistakes can be made. This problem is addressed in the present study through the use of general equilibrium modeling to estimate the economic effects of infrastructure investments. More specifically, it uses a large, two-region, multi-household applied general equilibrium model to estimate the regional economic impacts of the Second Mekong International Bridge spanning the Mekong River between Mukdahan Province in Thailand and Savannakhet

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Province in the Lao People's Democratic Republic (Lao PDR).[1] The bridge was completed in 2006 by the Asian Development Bank (ADB) and the Japan Bank for International Cooperation, in cooperation with the governments of Thailand and the Lao PDR.

Three aspects of the bridge's impact are important:

(i) It generates economic benefits to two relatively underdeveloped regions that have traditionally traded more extensively with the rest of the world than with each other. Despite being geographically close, Mukdahan and Savannakhet are separated by a substantial physical barrier: the Mekong River. Prior to the construction of the bridge, the river could be crossed by ferry for much of the year, but the process was costly. The bridge reduces the economic importance of this barrier, enabling closer integration between the two provinces.

(ii) As a consequence of this expansion in inter-regional trade, the bridge has distributional impacts within both Mukdahan and Savannakhet provinces and these distributional impacts could be important.

(iii) The bridge facilitates the development of a major road transport network, linking the People's Republic of China, Viet Nam, Lao PDR, Thailand, and (possibly in the future) Myanmar. There will consequently be benefits to all of these countries, and not just to Mukdahan and Savannakhet provinces.

In this study, we focus on the first and second of these issues: the benefits accruing to the two provinces directly adjacent to the bridge and the bridge's distributional impact within each. These two components of the overall impact have been the subject of much controversy. As with other infrastructure developments, some commentators presume that the bridge will mostly benefit other areas, and that benefits to the local economy of areas adjacent to the bridge itself will be insignificant at best. In addition, there is a presumption that within the locally affected areas, richer groups, meaning both richer regions and richer households within them, will be favored by the project relative to poorer groups. This paper explores whether these two presumptions are valid. It is important that since we do not attempt to quantify the economic benefits experienced outside these two provinces (the third aspect above), the analysis accounts for only part of the full economic effects of the bridge.

The analysis draws upon an inter-regional input–output table for Mukdahan and Savannakhet provinces, recently constructed by researchers at ADB (Sim, Secretario, and Suan 2007). This table is used to construct a two-region general equilibrium model linking the two provinces. The recognition of transport costs between the two regions is a feature of the general equilibrium

[1] An earlier bridge, completed in the mid-1990s, crosses the river between Nong Khai Province of Thailand and Vientiane Province of the Lao PDR.

structure that we develop. Cross-border infrastructure development is then modeled as a reduction in these inter-regional transport costs. The Sim et al. input–output structure is modified to allow for the explicit existence of transport margins, both within and between the two provinces. This modified structure is then used to construct an applied general equilibrium model describing a two-region economy, where Mukdahan and Savannakhet are the two regions, in which each region trades (i) internally, (ii) with the other region, and (iii) with the rest of the world and where each of these three forms of trade faces different transport cost barriers. These data are then combined with household survey data for both Mukdahan and Savannakhet provinces, assembled by the government statistical agencies of Thailand and the Lao PDR, respectively, to analyze the effects of improved inter-regional transport on poverty incidence and inequality in each of these two provinces. The result is a two-region, multi-sector, multi-household general equilibrium structure in which differential transport costs are explicitly recognized.

The magnitudes of reductions in inter-regional transport costs as a result of the bridge and its associated road connections are estimated using the Sim et al. data and other related studies. These transport cost reductions are then combined with the inter-regional general equilibrium model developed in this study to estimate their economic effects. The benefits are measured as effects on aggregate real consumption, poverty incidence, and inequality in each region. Other economic variables of interest, including the volumes of inter-provincial trade, are also discussed.

II. MUKDAHAN, SAVANNAKHET, AND THE EAST–WEST ECONOMIC CORRIDOR

The Second Mekong International Bridge is part of the 1,400-kilometer regional East–West Economic Corridor (EWEC), which runs from the coastal town of Mawlamyine in Myanmar to the port of Da Nang in western Viet Nam. The bridge links Mukdahan Province in northeastern Thailand and Savannakhet Province in central Lao PDR. Table 1 provides an overview of the economic conditions of economic hubs within EWEC, focusing on Mukdahan and Savannakhet.

Mukdahan is the second most important border cross-point between the Lao PDR and Thailand. In 2005, Mukdahan accounted for 16.4 percent of total official border trade between the two countries (Paitoonpong 2007).[2] Cross-border trade notwithstanding, Mukdahan is one of the poorest of Thailand's 76 provinces. Its population of 335 thousand is 0.51 percent of the national total but

[2]Nong Khai Province accounted for the majority share of 55.5 percent.

its gross provincial product (GPP) accounts for a little less than 0.13 percent of Thailand's gross domestic product (GDP).[3] Its GPP per capita of US$800 is, accordingly, roughly one quarter of the national average. Mukdahan is less industrialized than other EWEC economic hubs in Thailand. Manufacturing accounts for only 10 percent of its GPP, compared with 39 percent for Thailand as a whole. Mukdahan's service sector accounts for the bulk of GPP at roughly 46 percent, compared with 38 percent for Thailand.

Savannakhet's population of 843 thousand accounts for 14.7 percent of the Lao PDR's total population. Its GPP per capita is well below Mukdahan's, at US$525, although this is still roughly 85 percent of the Lao PDR's national average. Savannakhet is the largest and most populous of the Lao PDR's 18 provinces, with fertile land, forest, and mineral resources (Keorodom, Butphomvihane, and Vanhnalat 2007, Somphong 2003). The province has the largest share of rice production in the country (JICA 2007) and, not surprisingly, agriculture accounts for half of Savannakhet's GPP. It also has the largest number of industry-handicraft establishments, mostly small establishments engaged in wood products, garments, and food processing (Keorodom et al. 2007).

Table 1. **General Economic Structure within EWEC**

Economic Hub	Area (km^2)	GPP (US$ mn)	Population ('000)	GPP per Capita (US$)	Sector Shares of GPP (%)			
					Agriculture	Manufacturing	Other Industry	Services
Thailand	513,115	213,294	65,870	3,238	8.90	39.30	13.70	38.10
Mukdahan	4,339	268	335.447	800	18.32	10.28	25.42	45.98
Lao PDR	236,800	3,542	5,740	617	42.30	31.70	2.00	25.00
Savannakhet	21,774	443	843.245	525	50.00	25.00	0.00	25.00

EWEC = East–West Economic Corridor; GPP = gross provincial product; km^2 = kilometers squared; Lao PDR = Lao People's Democratic Republic.

Source: Centre for Logistics Research, Thammasat University and Supply Chain Engineering Management, Chiang Mai University and Lao People's Democratic Republic government estimates.

Table 2 provides the volume of trade between Mukdahan and Savannakhet, compared with other significant cross-border points in EWEC. Trade between the two provinces increased by more than 70 percent in 2007, following the completion of the Second Mekong International Bridge in December 2006. A reduction in export and import procedures at the Mukdahan border checkpoint has further facilitated cross-border trade. At present, import and export procedures at the Thailand and Lao PDR checkpoints require no more than 10 and 20 minutes, respectively. The Thai Customs Department's introduction of a paperless electronic customs system has also sped up customs procedures (Thai Government Public Relations Department 2008). Ongoing developments are expected to facilitate trade even further, including the implementation of the

[3]GPP is the provincial counterpart of GDP at the national level. The sum of GPP across all provinces is equal to GDP.

Greater Mekong Subregion Cross-Border Transport Agreement and the establishment of special economic zones in the two provinces.

Table 2. **Trade between Mukdahan and Savannakhet vs. Selected EWEC Cities (US$ million)**

Year	Tak		Mukdahan–Savannakhet		Dansavanh–Laobao	
	Thailand Imports from Myanmar	Myanmar Imports from Thailand	Lao PDR Imports from Thailand	Thailand Imports from Lao PDR	Lao PDR Imports from Viet Nam	Viet Nam Imports from Lao PDR
2000	16.85	97.54	138.27	36.31	…	…
2001	41.37	78.38	110.03	21.66	…	…
2002	20.72	88.33	99.74	22.04	13.71	11.90
2003	11.81	125.75	100.60	19.97	1.90	22.27
2004	15.77	288.36	146.00	16.81	3.11	32.47
2005	20.55	329.48	145.16	25.80	5.59	49.18
2006	33.92	315.18	168.56	78.82	13.97	107.31
2007	26.80	299.00	259.59	166.08	12.65	117.71

… = not applicable.
EWEC = East–West Economic Corridor; Lao PDR = Lao People's Democratic Republic.
Source: Centre for Logistics Research, Thammasat University and Supply Chain Engineering Management, Chiang Mai University.

A. The Cross-Border Transport Agreement and Special Economic Zones

The Cross-Border Transport Agreement is a comprehensive multilateral instrument covering several aspects of cross-border transport facilitation:

(i) one-stop customs inspection;
(ii) cross-border movement of persons (e.g., visas for persons engaged in transport operations);
(iii) transit traffic regimes, including exemptions from physical customs inspection, bond deposit, escort, and phytosanitary and veterinary inspection;
(iv) eligibility requirements for road vehicle cross-border traffic;
(v) exchange of commercial traffic rights; and
(vi) infrastructure, including road and bridge design standards, road signs, and signals (ADB 2009).

Full implementation of the Cross-Border Transport Agreement was expected in 2008. The proposed Savan–Seno Special Economic Zone is the Lao PDR's first special economic zone and will consist of three industrial sites, one of which (Site A) comprises an area of 305 hectares adjacent to the Second Mekong International Bridge in Savannakhet. Site A's facilities will focus on the service sector and include residential areas; three- to five-star hotels; a duty-free shop; an exhibition center; a golf course; and shopping, entertainment, and sports complexes (*Bangkok Post* 2009, Centre for Logistics Research, Thammasat

University and Supply Chain Engineering Management, Chiang Mai University 2008, JICA 2007). Meanwhile, the Industrial Estate Authority of Thailand plans to establish a logistics center and small industrial estate for light industries in Mukdahan (Tsuneishi 2007).

B. Impact of the Second Mekong International Bridge on Trade with Third Countries

The Mukdahan–Savannakhet border is an important gateway for trade not only between the Lao PDR and Thailand, but also among the People's Republic of China, Thailand, and Viet Nam. Most of the trading companies that conduct import and export activities between the Lao PDR and Viet Nam are located in the central district of Savannakhet Province. Goods are unloaded at storehouses by Lao PDR trading companies and these are either sold within the Lao PDR or re-exported. Re-exports make up the largest volume of trade in Savannakhet. Some goods and commodities are further processed in the Lao PDR before being exported to Thailand (Development Analysis Network 2005).

Initial estimates show that the Second Mekong International Bridge has led to significant reductions in trade transport costs between Thailand and Viet Nam, particularly between Hanoi and Bangkok. Table 3 summarizes available evidence on this point. The distance of travel between the two cities, previously about 2,000 kilometers by way of the First Mekong International Bridge in Nong Khai, was shortened to about 1,500 kilometers. The land trip between Bangkok and Hanoi takes 3–4 days passing through the new Second Mekong International Bridge, which represents 70 percent less travel time than coastal shipping (about 2 weeks) (JICA 2007, Tsuneishi 2007).

Table 3. **Inter-City Container Cargo Transport in the Greater Mekong Subregion**

Route	Land Transport			Sea Transport		Remarks
	Km	Day	Cost (US$)	Day	Cost (US$)	
Guangzhou–Hanoi	1,190	2	3,000	4–6	1,500	40 ft container including customs
HCMC–Hanoi	1,600	3–4	1,200	4–6	750	40 ft container domestic cargo
Bangkok–Hanoi	1,555	3–4	4,200	10–15	2,000	40 ft container including customs
Bangkok–HCMC	913	2	1,390	2–3	560	10 t truck and 20 ft container, excluding customs
Bangkok–Yangon	945	3	730	30	1,130	10 t truck and 20 ft container, excluding customs

ft = foot; HCMC = Ho Chi Minh City; km = kilometer; t = ton.
Source: JICA (2007).

In 2005, an important policy change was introduced by the government of the Lao PDR, with implications for the bridge, which opened the following year. The export of unprocessed logs to all destinations was banned. The purpose of the ban was partly to protect the forests of the Lao PDR and partly to encourage the

development of the domestic furniture industry. Table 7, which will be discussed in greater depth later on, shows that in 2003, exports of forestry products, which include unprocessed logs, were zero to Mukdahan but significant to the rest of the world. Exports of processed timber, including furniture, were significant to both destinations as these exports were exempted from the ban. The treatment of partially processed timber, such as sawn logs, is an important issue. According to available evidence, the export of all processed timber was effectively exempted from the ban. Exporters have adjusted their production activities to ensure that processed timber products meet the requirements for export clearance at the border.

III. THE UNDER-SUPPLY OF REGIONAL PUBLIC GOODS

There are reasons to think that infrastructure projects of this kind, linking regions of adjacent countries, are especially important for developing countries. According to Birdsall (2004), regional public goods in developing countries remain underfunded despite their potentially high returns, compared with traditional single-country-focused investments. The high returns arise from positive cross-border externalities or spillover effects, which are not necessarily taken into account in each individual country's investment decisions. Birdsall estimates that regional public goods receive only about 2.0 to 3.5 percent of total official development assistance. A combination of practical and political economy factors account for this low percentage.

First, under-investment can occur because of coordination failure. That is, the overall performance of the project depends on a coordinated outcome between all participating countries. In such circumstances, the relationship between performance and outcome, or inputs and outputs, breaks down at the country level for regional projects.[4] The uncertainty and risk of investing in a regional project are higher because the outcome of the project—and hence its benefit—depends upon the performance of other partners.[5] Furthermore, regional projects that

[4]To illustrate, consider a cross-border infrastructure project involving a road that runs from country A through country B to country C. Assume that the main function of the road is to facilitate trade between countries A and C, and that country B serves mainly as a transit route. In such a situation, country B would question the benefit that it would derive from the cross-border project. Both countries A and C would be aware of country B's concerns, as well as its interest in and commitment to the project. Coordination failure occurs if country B fails to participate in the project due to perceived unequal benefits, or if countries A or C hesitate because of the awareness of this likelihood, recognizing that success is a joint product. For a lucid discussion of assignment problems associated with coordination failure, see Estevadeordal, Frantz, and Nguyen (2005).

[5]That is, the contribution made by one country to the success of a regional project depends upon other countries also contributing. This cannot be ensured or enforced for several reasons: (i) participating countries might have different priorities and attach different weights to a regional project, (ii) commitment to the project's success might change along with domestic political and economic circumstances, or (iii) domestic resource constraints or institutional weaknesses could prevent countries from participating fully.

produce largely regional (as opposed to national) public goods can also have significant asymmetries in costs and benefits across countries that result in further under-investment in such projects.

Second, according to Birdsall, bilateral aid agencies tend to prefer country-based transfers because they have the potential to provide greater geo-strategic and political benefits. Even within multilateral development agencies, the recent emphasis on countries' ownership of their own development priorities has often favored national programs over regional ones.

In this paper, we examine the extent to which such asymmetries may operate in the context of a specific cross-border regional project: the Second Mekong International Bridge. The bridge created, for the first time, a direct road link between these two adjacent provinces. The width of the Mekong River at this point is around two kilometers and the length of the two-lane bridge crossing it is about four kilometers. Subsequently, ADB and the governments of the two countries implemented agreements on road construction on each side of the bridge and cooperation in the areas of customs, immigration, and quarantine to promote transport and trade facilitation. Each side of the bridge is connected to the country's national road network. All efforts are directed toward reducing the cost of trading between the provinces of these two neighboring countries, thereby improving human welfare in both countries.

These infrastructure investments, and others like them, can reasonably be expected to reduce transport costs and promote trade between the two provinces and with the rest of the world. But how will these economic changes affect economic welfare in the two provinces, and to what extent will the impacts differ? This study applies a general equilibrium modeling framework to answering these questions.[6]

IV. THE UNOBSERVED COUNTERFACTUAL AND THE ROLE OF ECONOMIC MODELING

Benefit-cost analysis of an investment project requires comparing outcomes that occur in the presence of the project with those that would have occurred in its absence. At least one component of this comparison is always hypothetical. This essential point applies whether the analysis is conducted before (ex ante) or after (ex post) the investment is undertaken. In the case of ex ante assessment, both the outcomes of the project and the counterfactual—what would have happened without the project—involve hypothetical projections into the future. Both of these forms of analysis are important, but ex ante assessment is more crucial in that it may influence decisions about whether the investment

[6]An earlier study, which applied a similar general equilibrium methodology to study the benefits of rural road upgrading within the Lao PDR itself, is Menon and Warr (2008).

should occur. Ex post analysis is useful mainly in the lessons it may provide for the way ex ante analyses should be conducted.

In the case of ex post evaluations, the actual outcomes of the project may be known in the sense that data can exist on the historical inputs and outputs associated with the project. But these data can never reveal what would have happened if the project had not existed. As noted above, measuring the impact of the project necessarily involves the *difference* between what happens in the presence of the project with something hypothetical. The former can potentially be observed empirically, when the project already exists, but the latter cannot be observed and can only be estimated. It follows that data alone can never provide all the information needed for benefit-cost analysis. The essential problem arises for both project benefits and project costs, but is probably most acute in the case of project benefits.

Benefit-cost analysts use a variety of methods to deal with this problem. The construction of a counterfactual requires an economic model, even if the model is implicit. The present paper explores the use of general equilibrium modeling to estimate ex ante project benefits. It does this by simulating the full economic impact of the shocks that the existence of the project introduces into the local economy. The focus of the paper is on determining the size of these impacts—the project benefits—rather than the implications of these results for the economic desirability of this particular project, which would involve study of the project's economic costs as well.

V. THE MUKDAHAN–SAVANNAKHET INPUT–OUTPUT TABLE

The input–output table constructed by Sim et al. (2007), referred to here as the Mukdahan–Savannakhet input–output table (subsequently MSIO table), describes transactions between Mukdahan and Savannakhet, and between these provinces and the rest of the world, constructed using data from the year 2003. It specifies 20 production sectors in each region. All values are specified in producer prices and are measured in United States (US) dollars. The transactions matrix has 60 rows and 40 columns. It describes the use of 20 types of intermediate goods from each of Mukdahan, Savannakhet, and the rest of the world as inputs into each of the 20 industries located in Mukdahan and Savannakhet provinces. The rest of the world category refers to all other provinces of Thailand and the Lao PDR, as well as to all other countries.

Within the MSIO structure, there are no transport costs or other margins occurring between production and final users. In understanding this point, it is helpful to caricature the model as one in which the final users—including consumers, investors, and the government—reside permanently at the factory gates themselves, waiting for the goods to reach them. For the purposes of the

present study, this structure was modified to create transport margins between firms and final users, where these margins are not necessarily the same for inter-regional exchanges (i.e., between Mukdahan and Savannakhet) as they are for intra-regional exchanges (i.e., within each of these two regions).

One of the 20 industries is transport, which is used as an intermediate input into the production of each of the other industry outputs. Instead of treating transport as a pure intermediate good used directly in the production of output at producer prices, we allocate part of the output of this industry to the production of transport margins between production and final demand. We arbitrarily allocate 90 percent of all transport use to this margin category, leaving 10 percent for direct intermediate usage. The effect of this reallocation is that producer prices implicitly decline somewhat, but purchaser prices and GPP do not change.

Since the input–output structure identifies the use of inputs from each region in production in the other, this procedure leads to the estimation of transport margins per unit of sales, both for intra-regional sales within each of the two regions and inter-regional sales between them (in both directions). The results of this exercise are summarized in Table 4. Transport costs within Mukdahan itself are estimated to be 2.4 percent of final sales, but transport costs from Mukdahan to Savannakhet are 6.5 percent of sales. Inter-regional trade from Mukdahan to Savannakhet incurs a transport cost premium of 164 percent relative to intra-regional trade within Mukdahan itself. Similarly, inter-regional trade from Savannakhet to Mukdahan incurs transport costs of 4.3 percent of sales, compared to trade within Savannakhet itself of less than 0.1 percent. This implies a transport cost premium for inter-regional trade from Savannakhet to Mukdahan of 97 percent.[7]

Table 4. **Transport Margins (percentage of sales)**

		To:	
		Mukdahan	**Savannakhet**
From:	Mukdahan	2.36	6.52
	Savannakhet	4.27	0.08

Source: Authors' calculations based on Sim et al. (2007).

Final demand in the two provinces is summarized in Table 5. GPP is the sum of rows 1–9, which explains the negative signs before imports from the rest of the world. Although Savannakhet is considerably poorer than Mukdahan in per capita terms, its much larger population means that Savannakhet's economy is somewhat larger, with GPP of US$339 million compared to Mukdahan's

[7]Conducting the same exercise was considered for the somewhat larger trade industry. However, according to the Sim et al. data set, the inter-regional use of this intermediate good is zero. It appears as an intermediate good only for intra-regional trade. Using the method of this paper, the estimated inter-regional trade margins corresponding to this industry would therefore be zero.

US$232 million. The initial value of sales from Mukdahan to Savannakhet is about triple the value of sales in the opposite direction.

Table 5. **Final Demand in Mukdahan and Savannakhet Provinces in 2003 (US$'000)**

	Mukdahan	Savannakhet
Household consumption	173,258	290,354
Investment	57,861	109,119
Government	36,487	8,957
Stocks	4,572	11,817
Exports to ROW	90,808	76,927
Imports from ROW	–135,518	–153,689
Regional exports	6,392	2,002
Regional imports	–2,002	–6,392
Net margin	357	–357
Total GPP	232,215	338,738

GPP = gross provincial product; ROW = rest of the world.
Note: ROW does not include the partner region (Mukdahan or Savannakhet). The category of net margin is explained in the text.
Source: Authors' calculations based on Sim et al. (2007).

The meaning of "net margin" in Table 5 requires explanation. It should be recalled that the input–output table is compiled in producers' prices rather than purchasers' prices. Transport margins are assumed to be supplied in the source region rather than the destination region. Net margin is the difference between the value of the margins supplied in the source region in delivering sales to the other region, and the value of the margins purchased from the other region in the form of the goods purchased from it. Margins supplied to inter-regional trade are essentially exports of services that need to be counted in GPP, but they are not counted when the goods are valued solely at producer prices, since these prices exclude margins. In this circumstance, a separate category is required to account for these margins. This is an accounting issue that does not arise for trade with the rest of the world, because free-on-board prices for exports and cost, insurance, and freight prices for imports already allow for these margins. Since inter-regional sales from one region are equivalent to inter-regional purchases from the other, the net margin balance of one region must be equal and opposite in sign (i.e., positive or negative) to the net margin balance of the other.

Table 6 summarizes sales within the Mukdahan–Savannakhet regional economy, distinguishing between intra-regional sales and inter-regional sales. For Mukdahan, sales to Savannakhet were valued at US$6.4 million, representing just 1.6 percent of Mukdahan's total sales within the region (not including exports to the rest of the world). For Savannakhet, sales to Mukdahan were valued at US$2.0 million, representing only 0.3 percent of Savannakhet's total regional sales. The data suggest that the base level of inter-regional trade between these two provinces is very small. As Table 5 shows, exports to the rest of the world were more important for Mukdahan by a factor of about 14, and more important for Savannakhet by a factor of more than 30. The commodity composition of

these inter-regional sales is summarized in Table 7. For Mukdahan, sales to Savannakhet were dominated by food and textiles; for Savannakhet, sales to Mukdahan were dominated by wood and paper products.

Table 6. **Total Sales within the Mukdahan–Savannakhet Regional Economy in 2003 (US$'000)**

To: / From:	Mukdahan	Savannakhet	Total
Mukdahan	393,203	6,392	399,595
Savannakhet	2,002	585,411	587,413
Total	395,205	591,803	987,008

Source: Authors' calculations based on Sim et al. (2007).

Table 7. **Initial Levels of Inter-Regional Trade in 2003 (US$'000)**

	Exports from Mukdahan to Savannakhet	Exports from Mukdahan to the Rest of the World	Exports from Savannakhet to Mukdahan	Exports from Savannakhet to the Rest of the World
Crops	0.7	23,580	342	4,150
Livestock	13.8	2	20	11,096
Forestry	4.5	34	0	1,120
Mining	0.0	2,300	0.9	30,746
Food	3,192	13,483	3	16,440
Textiles	1,464	6,652	23	977
Wood and paper	17	98	1,604	1,795
Chemicals	100	0	0	0
Minerals	999	82	0	0
Machinery	553	0	0	0
Construction	0	126	0	0
Transport	50	6,439	10	319
Telecom	0	141	0	479
Trade	0	6,040	0	5,889
Personal services	0	32,079	0	35,940
Total	**6,392**	**91,055**	**2,002**	**167,925**

Note: Categories in which all entries are zero have been deleted for brevity. For the full list of all 20 industries, see Table 14.

Source: Authors' calculations based on Sim et al. (2007).

VI. THE MUKDAHAN–SAVANNAKHET REGIONAL GENERAL EQUILIBRIUM MODEL

This section describes a general equilibrium model of the Mukdahan and Savannakhet regional economy, constructed specifically for the purpose of this study and based on the modified version of the MSIO table summarized above. For brevity, the resulting general equilibrium model will subsequently be called M-SGEM. Its relationship to the more familiar single-country general equilibrium models, which exist for many countries, is that we imagine Mukdahan and Savannakhet to be two regions of a single economy trading with the outside world. The outside world includes all other

provinces of Thailand and the Lao PDR, and all other countries. M-SGEM includes the specification of two-way transport costs between the two regions, Mukdahan and Savannakhet. The shock to this economy that will form the core of the analysis is a reduction in these two-way, inter-regional transport costs, corresponding to the estimated transport cost reductions arising from the construction of the bridge and its associated road connections.

Unless otherwise stated, the data base of the model refers to the year 2003, the year described in the MSIO table summarized above. The bridge did not open until 2006, so the analysis assumes that the structure of the Mukdahan–Savannakhet regional economy was roughly the same in 2006 as it was in 2003. The model's main features are as follows.

A. Model Structure

The theoretical structure of M-SGEM is relatively conventional. It belongs to the class of general equilibrium models that are linear in proportional changes, sometimes referred to as Johansen models. The highly influential ORANI general equilibrium model of the Australian economy (Dixon et al. 1982) uses this approach, as does the Global Trade Analysis Project model of the global economy (Hertel 1999). The detailed structure of M-SGEM is based on the TERM general equilibrium model of the Australian economy (Horridge, Madden, and Wittwer 2005).[8] However, this general structure is adapted to reflect the specific objectives of the present study and important features of the Thai and Lao PDR economies.

The microeconomic behavior assumed within M-SGEM is competitive profit maximization on the part of all firms, and competitive utility maximization on the part of consumers. Each industry in each region has constant returns-to-scale technology and there is at least one industry-specific factor present in each industry. In the simulations, the markets for final outputs, intermediate goods, and factors of production are all assumed to clear at prices that are determined endogenously within the model.[9]

The currency used within the data base of M-SGEM is the US dollar. Its (imaginary) exchange rate relative to the rest of the world is fixed exogenously and its role within the model is to determine, along with international prices, the nominal domestic price level. The model is homogeneous (degree one for prices and degree zero for quantities) with respect to this exchange rate. Therefore, if domestic prices were to adjust flexibly to clear markets, then a 1.0 percent

[8] TERM is an acronym denoting "the enormous regional model" and refers to a 67-region model of the Australian economy. The theoretical structure of M-SGEM borrows heavily from the structure of TERM and from elements of a revised version of the ORANI model of the Australian economy called ORANI-G (Horridge 2004).

[9] Variations to this assumption are possible. For example, the possibility of unemployment can be introduced by varying the closure to make either real or nominal wages exogenous, thereby allowing the level of employment to be endogenously determined by demand.

increase in the exchange rate would result in a 1.0 percent increase in all nominal domestic prices, leaving all real variables unchanged.

B. Industries

The model contains 20 industries in each of the two regions, based on the MSIO table. They include three agricultural industries: crops, livestock and poultry, and forestry and logging. The non-agricultural industries are mining and quarrying; seven manufacturing industries; and nine services and utilities industries, one of which is transport. The transport industry is especially important for the present study. Each industry produces a single output, and the set of commodities coincides with the set of industries.

C. Commodities

An Armington structure is used to relate domestic production, consumption, international trade, and inter-regional trade. The price definitions used within this structure are summarized in Table 8. For each commodity, the commodity name appears as a superscript. There are also two subscripts denoting the source and destination of the commodity, respectively. Thus, P^i_{MS} denotes the price of good *i* produced in source *M* (Mukdahan) and sold in destination *S* (Savannakhet). Goods originating from the rest of the world (imports) are denoted by * for source. Thus, the price of imports of good *i* produced in the rest of the world and sold in Mukdahan is denoted by P^i_{*M}. In the case of exports, a destination in the rest of the world is denoted by *, so the price of good *i* that originates in Savannakhet and is sold in foreign markets (exports) is denoted by P^i_{S*}.

Table 8. **Price Definitions**

		Destination		
		Mukdahan	**Savannakhet**	**Export**
Source	**Mukdahan**	P^i_{MM}	P^i_{MS}	P^i_{MM}
	Savannakhet	P^i_{SM}	P^i_{SS}	P^i_{S*}
	Import	P^i_{*M}	P^i_{*S}	…
	Domestic	P^i_{DM}	P^i_{DS}	…
	Consumer	P^i_{CM}	P^i_{CS}	…

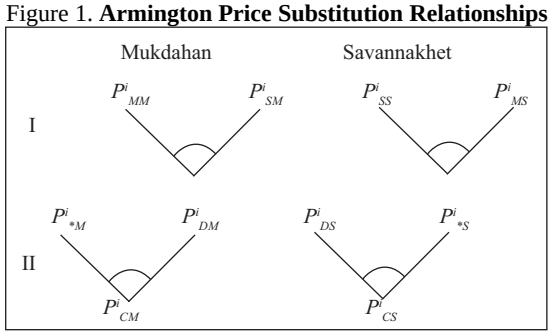
… = not applicable.

The structure of commodity substitution is summarized in Figure 1. Armington substitution occurs at two levels. We will take the case of goods sold in Mukdahan (destination M) as an illustration. First, a good produced in

Mukdahan and sold in Mukdahan (price P^i_{MM}) substitutes imperfectly with a similar good produced in Savannakhet and sold in Mukdahan (price P^i_{SM}) to produce the domestic version of the good (price P^i_{DM}). This substitution process is denoted as Level I in Figure 1. This domestic version of the good is an imperfect substitute for final users, with the imported version of the good (price P^i_{*M}) denoted in Level II. The price to final users (such as consumers) of the resulting composite commodity is denoted by P^i_{CM}.

Although the sets of producer goods and consumer goods have the same names, the commodities themselves are not identical. Each of the 20 consumed goods consists of a composite of the domestically produced and imported version of the same commodity, where the two are imperfect substitutes. The domestically produced version is an Armington composite of goods produced in the two regions. The proportion in which they are combined reflects consumer choices and depends on both (i) the relative prices of these imported and domestically produced versions of the good, and (ii) the Armington elasticity of substitution between them.

Figure 1. **Armington Price Substitution Relationships**



Note: I denotes the first level of the Armington substitution process, in which goods from the two regions substitute for one another to produce a "domestic" good within each region. Similarly, II denotes the second level, in which the domestic goods and imports substitute for one another to produce a "composite" good. P^i_{jk} denotes the price of good i from source j in destination k, where S denotes Savannakhet, M denotes Mukdahan, D denotes domestic, * denotes imports, and C denotes composite. Thus, for example, P^5_{SM} denotes the price of good 5, derived from Savannakhet (source S) and sold in the Mukdahan market (destination M).

D. Factors of Production

The mobility of factors of production is a critical feature of any general equilibrium model, where the term mobility means the capacity to move across economic activities (industries) and not necessarily the capacity to move geographically. The greater the inter-sectoral factor mobility built into the model, the more flexible the economy, as reflected in its simulated capacity to respond to

changes in the economic environment. It is essential that assumptions about the mobility of factors of production be consistent with the length of run that the model is intended to capture.

There are two treatments for the mobility of labor, capital, and agricultural land, reflecting two different periods of adjustment:

In the **short-run treatment**, within each province, labor is mobile across all industries, but capital and agricultural land are each immobile across industries. The short-run assumptions represent a length of time for adjustment that is sufficient for the movement of labor among industries in response to changes in rates of return to labor, but insufficient for the reallocation of capital through investment and disinvestment in capital stocks, or for the reallocation of land via crop substitution. These strong assumptions on capital immobility mean that the short run represents an adjustment period of two to three years.

In the **long-run treatment**, labor is mobile between Mukdahan Province and the rest of Thailand, and the real wage within Mukdahan is determined exogenously by the real wage within Thailand. Similarly, labor is mobile between Savannakhet and the rest of the Lao PDR at an exogenous real wage. Labor is not mobile between Mukdahan and Savannakhet. Capital is mobile both across industries and internationally. The rate of return is exogenously fixed and is determined by the international rate of return. Agricultural land is mobile across agricultural industries, but fixed in total supply.

In the long run, labor moves from the rest of Thailand into Mukdahan, or vice versa, in response to changes in the real wage within Mukdahan. The same mobility occurs between Savannakhet and the rest of the Lao PDR. Capital stocks adjust through international movement of capital sufficient to equalize rates of return to capital across industries. In addition, agricultural land moves across agricultural industries, meaning that the commodities produced on particular pieces of land adjust in response to changes in the rate of return to land. However, the total supply of agricultural land remains the same. These long-run assumptions are designed to represent a duration for adjustment of approximately 10 years.

E. Technology

In every sector there is a constant elasticity of substitution production technology with diminishing returns to scale to variable factors alone. However, there is also a sector-specific fixed factor (immobile capital or land) in every sector. Constant returns to scale apply with respect to all factors together. This assumption implies that (i) each factor demand function is homogeneous of degree one in output; and (ii) in each sector, there is a zero profit condition, which equates the price of output to the minimum unit cost of production. This

condition can be thought of as determining the price of the specific factor in that sector.

F. Households

The model incorporates multiple households within Mukdahan and Savannakhet, thus creating the capability to generate income distributional results within each region. The data used for this purpose are household income and expenditure data for these provinces, assembled by the national statistical agencies of each country. In the original data, the number of households was 244 in Mukdahan and 718 in Savannakhet. The number of households was aggregated to 100 in each province for the purpose of this analysis.

The analytical approach is the widely used top-down method, in which price changes and nominal income changes produced by the top-level computable general equilibrium (CGE) model (excluding the multi-household structure) are transferred to a separate (bottom-level) micro-simulation model that contains the multi-household data. The bottom-level model is used to estimate the implications that the price and nominal income changes have for poverty incidence and inequality. Price and income changes are exogenous in this bottom-level micro-model. Bourguignon, Robilliard, and Robinson (2003) is among many earlier studies adopting this approach. The ideal approach to distributional analysis would presumably be the use of disaggregated households, integrated into the CGE model when all observations in the household survey are represented. But this is costly and unnecessary. By using only a smaller number of representative households (say 100) classified by expenditure (or income) per capita, the calculation of poverty and inequality indicators can be quite accurate.

Poverty incidence is now calculated as follows. We shall first describe the calculation of poverty incidence ex ante (before the project). We first sort the raw data on household expenditures per capita, arranging them according to expenditures per capita, from the poorest to the richest. These data are then divided into centile groups, with equal population in each of the 100 categories. Let y_c be real expenditure per capita of a household of the c^{th} centile where c = 1, 2, …, n, and n = 100. That is, y_1 is the poorest centile group, y_{100} is the richest, and by construction, $y_{i+1} \geq y_i$, where i = 1, 2, …, n. Poverty incidence is now

$$P(y_c, y_P) = \max\left\{c \middle| y_c < y_P\right\} + \frac{y_P - \max\left\{y_c \middle| y_c < y_P\right\}}{\min\left\{y_c \middle| y_c > y_P\right\} - \max\left\{y_c \middle| y_c < y_P\right\}}, \quad (1)$$

where y_P is the poverty line. The first term is simply the lowest centile for which expenditure per capita is closest to the poverty line. The second term is the linear approximation to where poverty incidence lies between centiles c and c+1.

The general equilibrium simulation of the impact of a particular shock (in this case a project) generates estimated percentage changes in the distribution of real per capita expenditures. The meaning of "real" is that the deflators used to obtain the distribution of real expenditures from the distribution of nominal expenditures are indices of consumer prices specific to the centile categories concerned. They are calculated using the budget shares corresponding to each centile group. Let $\hat{y}_c$ denote the estimated percentage change in the real expenditure per capita of centile group *c*. The estimated ex post (after the project) level of real expenditure per capita as estimated by the general equilibrium model is given by y_c^*, where

$$y_c^* = \left(1 + \frac{\hat{y}_c}{100}\right).y_c \,. \tag{2}$$

It is important to note that different centile categories may be affected quite differently by the project, as captured by the simulation results. This means that the ordering of centile groups according to their ex post real expenditures per capita may have changed. It is not necessarily the case that $y_{i+1}^* \geq y_i^*$. Accordingly, the method of equation (1) above cannot be applied directly to the distribution y_c^*. The 100 household categories in the ex post distribution y_c^* are now *re-sorted* according to real expenditures per capita in the same way as described above, to obtain a new distribution y_c^{**} such that $y_{i+1}^{**} \geq y_i^{**}$. The distribution y_c^{**} differs from the distribution y_c^* only by this re-sorting. It is notable that because of the re-sorting the i^{th} centile group in the re-sorted ex post distribution y_c^{**} does not necessarily correspond to the i^{th} centile group in the ex ante distribution y_c.

The re-sorted ex post distribution y_c^{**} of real expenditures per capita is then used as the basis for recalculating the poverty incidence in the same manner as in equation (1), substituting the distribution y_c^{**} for the distribution y_c to obtain $P(y_c^{**}, y_P)$. The poverty line is held constant in real terms and so the same poverty line y_P can be used to calculate poverty incidence in the ex ante and ex post distributions because both represent *real* household expenditures per capita. The change in poverty incidence after a policy shock (simulation) is now

$$\Delta P = P(y_c^{**}, y_P) - P(y_c, y_P) \,. \tag{3}$$

That is, the same method is used to calculate the level of poverty incidence in the ex ante and the *re-sorted* ex post distributions. The change in poverty

incidence is simply the difference between them. This methodology was first applied in Warr (2005).

G. Elasticity Estimates

The elasticity estimates used in M-SGEM are standard default elasticities widely used within general equilibrium models of this type. The CES elasticities of factor substitution in production are set at 0.5 in all cases. Referring to Figure 1, Armington elasticities of substitution at Level I are set at 2, and at Level II they are set at 5. All export demand elasticities were set at 20. The elasticities of supply of imports to the Mukdahan–Savannakhet economy are assumed to be infinite and import prices were, therefore, set exogenously.

H. Treatment of Transport Costs

The information on transport costs described above was used to allocate the output of the transport industry in the input–output table to transport margins between final and producer prices in each of the four household categories. The important case is inter-regional transport margins, where the price relationships are:

$$P^i_{MS} = P^i_{MM}(1+V^i_{MS}) \tag{4}$$

$$P^i_{SM} = P^i_{SS}(1+V^i_{SM}), \tag{5}$$

where, as before, P^i_{MS} is the price of good i in destination M (Mukdahan) from source S (Savannakhet), and so forth, while V^i_{MS} and V^i_{SM} are the inter-regional proportional rates of transport cost from Mukdahan to Savannakhet and vice versa, respectively.

VII. SIMULATIONS AND RESULTS

A. The Shocks

Table 4 above confirms that before the existence of the bridge and its connecting roads, transport costs per unit of final sales were higher for inter-regional trade than for intra-regional trade. The bridge links the two provinces more efficiently and thereby reduces inter-regional transport costs. In the simulations reported here, the bridge is represented as a reduction in this differential between inter-regional and intra-regional transport costs to zero. Specifically, transport costs between regions are reduced to the same level as transport costs within regions. Transport costs for intra-regional trade remain

unchanged because these do not involve crossing the river. It is thus assumed that only inter-regional transport costs are affected by the existence of the bridge. The modeling mechanism by which transport costs are reduced is through neutral technical change in all inputs directly involved in producing inter-regional transport costs. These assumptions are intended to be indicative of what might reasonably be expected, based on other studies of the effects of major infrastructure developments of this kind.

Table 9 summarizes these shocks. Inter-regional transport costs from Mukdahan to Savannakhet are reduced from 6.52 percent of final sales to 2.36 percent, representing an absolute reduction of 4.16 percent as a percentage of total sales. Transport costs in the reverse direction are reduced by an almost identical absolute amount of 4.19 percent of total sales.

Table 9. **Shocks to Inter-Regional Transport Margins**

	Reductions in Transport Costs (% of total sales)	
To:	**Mukdahan**	**Savannakhet**
From:		
Mukdahan	0	–4.16
Savannakhet	–4.19	0

Source: Authors' calculations.

B. Model Closure

The simulations differ according to the length of run over which the analysis is conducted, by varying the assumed mobility of factors of production, as described above. Simulations 1 and 2 refer to the short-run and long-run mobility assumptions, respectively.

Since real household consumption expenditure is chosen as the basis for welfare measurement, the macroeconomic closure must be made compatible with both this measure and with the single-period horizon of the model. This is done by ensuring that the full economic effects of the shocks are channeled into current-period household consumption and do not "leak" in other directions, causing real-world inter-temporal welfare implications to escape being captured by the welfare measure. The choice of macroeconomic closure may thus be seen in part as a mechanism for minimizing inconsistencies between the use of a single-period model to analyze welfare results, and the multi-period reality that the model depicts.

To prevent inter-temporal and other welfare leakages from occurring, the simulations are conducted with balanced trade (exogenous balance on current account) in each region. Balanced trade means that for each of the two regions, the change in the value of net exports (gross exports minus gross imports) to the rest of the world plus the change in the value of net exports (sales minus purchases) to the other region must sum to zero. This ensures that the potential

benefits from the shock do not flow to foreigners through a current account surplus, and that increases in domestic consumption are not achieved at the expense of borrowing from abroad in the case of a current account deficit. For the same reason, real government spending on each good is fixed exogenously. The government budget deficit is fixed in nominal terms. This is achieved by endogenous across-the-board adjustments to the sales tax rate, so as to restore the base level of the budgetary deficit. The combined effect of these features of the closure is that the full effects of changes in policy are channeled into household consumption and not into effects not captured within the single-period focus of the model.

Finally, in recognition of the Lao PDR government's export ban on logs, changes in exports of forestry products (meaning logs but not products made from them) are constrained to zero. This is achieved within the model by treating the level of these exports from Savannakhet to Mukdahan and to the rest of the world as exogenously fixed and by setting taxes on exports of forestry products to these two destinations. The level of these taxes adjusts endogenously to prevent any such changes in forestry exports from occurring.

C. Results: Short Run

Table 10 summarizes the short-run macroeconomic effects of the reductions in transport costs described above. This table, and each subsequent table of results, shows both the percentage change and the absolute change in each variable. The absolute change is equal to the percentage change multiplied by the initial level of the variable, divided by 100 and expressed in thousands of US dollars.

Table 10. **Summary of Macroeconomic Results in the Short Run**

	Percentage Change		**Absolute Change (US$'000)**	
	Mukdahan	**Savannakhet**	**Mukdahan**	**Savannakhet**
Real GPP	0.040	0.087	93.49	294.48
Real household consumption	0.073	0.091	126.58	263.28
Real exports to ROW	–0.263	0.044	–238.85	33.82
Real imports from ROW	–0.101	–0.038	–136.30	–58.48
Sales to other region	8.820	16.020	565.47	321.32
Purchases from other region	16.020	8.820	321.32	565.47

GPP = gross provincial product; ROW = rest of the world.
Note: ROW does not include the partner region (Mukdahan or Savannakhet).
Source: Authors' calculations.

In general, the estimated short-run impacts are quite small. Both the proportional and the absolute increase in real GPP is larger in Savannakhet than in Mukdahan. A similar result applies to the change in real consumption. It is not

the case that the richer region (Mukdahan) enjoys all, or even most, of the benefits from the improved infrastructure. The absolute increase in Savannakhet exceeds that in Mukdahan by an even larger margin because the initial level of GPP (and real consumption) was higher. Table 11 shows the absolute change in nominal GPP and its components. The absolute price level rises in Mukdahan and falls slightly in Savannakhet. Both regional and non-regional exports[10] increase in Savannakhet, but for Mukdahan, the increase in regional exports is partly at the expense of a decline in exports to the rest of the world. Similarly, the increase in regional imports in both regions is partly at the expense of a decline in imports from the rest of the world.

Table 11. **Change in Composition of Nominal GPP in the Short Run**

	Percentage Change		**Absolute Change (US$'000)**	
	Mukdahan	**Savannakhet**	**Mukdahan**	**Savannakhet**
GPP	0.072	0.072	167.36	244.25
Household consumption	0.100	0.074	173.20	213.96
Investment	–0.022	0.024	–12.87	26.67
Government spending	–0.019	0.043	–6.85	3.81
Stocks	0.304	–0.002	13.89	–0.20
Non-regional exports	–0.250	0.042	–226.91	32.13
Non-regional imports (–)	0.101	0.038	136.30	58.48
Regional exports	9.461	16.494	604.76	330.17
Regional imports (–)	–16.494	–9.461	–330.17	–604.76
Net margin	–51.598	–51.598	–183.99	183.99

GPP = gross provincial product.

Note: Imports enter the table with a negative sign because of the national accounting identity that gross domestic product is equal to consumption plus investment plus government spending plus exports, minus imports. Consequently, the table indicates that non-regional imports decline in both regions (row 7) and regional imports increase in both regions (row 9).

Source: Authors' calculations.

Table 12 shows the composition of the changes in inter-regional trade. Increased exports from Mukdahan are moderate in total (US$0.6 million) and are concentrated in food and textiles. The increased exports from Savannakhet are only half as large in total and mostly take the form of processed timber products and crops. Table 13 shows a corresponding decline in exports to the rest of the world in each of the four categories just mentioned. The reduced inter-regional transport costs have caused some increase in total exports and also a significant re-allocation of exports from the rest of the world to the regional trading partner, to whom transport costs have fallen.

[10]Non-regional exports refers to exports from Mukdahan to locations other than Savannakhet, and from Savannakhet to locations other than Mukdahan.

Table 12. **Composition of Changes in Inter-Regional Trade in the Short Run**

	Percentage Change		Absolute Change (US$'000)	
	Mukdahan	**Savannakhet**	**Mukdahan**	**Savannakhet**
Crops	8.826	8.895	0.06	30.44
Livestock	8.779	8.991	1.21	1.75
Forestry	8.970	0.000	0.40	0.00
Mining	0.000	8.943	0.00	0.08
Food	8.744	8.731	279.10	0.25
Textiles	10.353	6.216	151.61	1.40
Wood and paper	–1.539	17.674	–0.26	283.45
Chemicals	11.754	0.000	11.71	0.00
Minerals	4.278	0.000	42.73	0.00
Machinery	7.879	0.000	43.54	0.00
Transport	69.737	33.155	34.55	3.29

Note: Categories in which all entries are equal to zero have been deleted for brevity. For the full list of all 20 industries, see Table 14.
Source: Authors' calculations.

Table 13. **Change in Exports to the Rest of the World in the Short Run**

	Percentage Change		Absolute Change (US$'000)	
	Mukdahan	**Savannakhet**	**Mukdahan**	**Savannakhet**
Crops	0.001	–0.847	0.37	–37.92
Livestock	–0.611	–0.183	–0.01	–21.97
Forestry	–1.498	0.000	–0.58	0.00
Mining	–0.028	–0.013	–0.74	–4.47
Food	–1.632	0.738	–250.45	130.93
Textiles	–1.962	9.779	–148.48	102.85
Wood and paper	84.686	–9.032	87.04	–174.97
Chemicals	–6.924	25.948	0.00	0.00
Minerals	–38.086	12.026	–35.36	0.00
Machinery	–10.395	2.882	0.00	0.00
Other manufacturing	0.000	–0.262	0.00	0.00
Electricity and water	–0.270	–0.143	0.00	0.00
Construction	0.556	–0.554	0.80	0.00
Transport	18.919	167.785	138.51	57.51
Telecom	–0.875	–0.026	–1.41	–0.13
Trade	1.356	0.432	9.32	2.75
Banking	0.249	–1.120	0.00	0.00
Real estate	–1.801	–1.412	0.00	0.00
Public sector	0.376	–0.847	0.00	0.00
Personal services	–0.097	–0.443	–35.25	–18.45

Source: Authors' calculations.

As Table 14 shows, output increases in each of the two regions in the food and textiles sectors, but declines in the transport sectors of both regions, reflecting the greater productivity of the transport system as a result of the bridge.

Table 14. **Changes in Industry Outputs in the Short Run**

	Percentage Change		Absolute Change (US$'000)	
	Mukdahan	**Savannakhet**	**Mukdahan**	**Savannakhet**
Crops	0.009	0.003	5.73	1.58
Livestock	0.008	–0.005	1.19	–6.48
Forestry	0.029	0.035	0.10	2.40
Mining	0.002	–0.013	0.10	–4.02
Food	0.097	0.015	94.04	28.61
Textiles	0.091	0.356	10.58	17.26
Wood and paper	1.063	0.176	1.72	19.05
Chemicals	0.367	0.627	2.24	0.59
Minerals	0.915	0.275	6.22	1.70
Machinery	2.210	0.079	24.99	5.67
Other manufacturing	0.000	–0.001	0.00	–0.06
Electricity and water	0.017	–0.014	1.14	–0.66
Construction	0.002	0.000	0.83	–0.14
Transport	–0.819	–6.513	–96.26	–43.70
Telecom	0.017	–0.017	1.52	–0.11
Trade	–0.024	–0.023	–11.63	–11.80
Banking	0.045	0.001	6.22	0.04
Real estate	0.008	0.003	1.07	0.28
Public sector	0.000	0.011	0.00	1.33
Personal services	0.005	0.000	4.67	–0.20

Source: Authors' calculations.

Finally, Table 15 shows the estimated changes in poverty incidence and inequality in the short run. Consistent with the small changes in aggregate real consumption expenditures described above in Table 10, reductions in poverty incidence are also small. Inequality rises somewhat in Savannakhet and the resulting short-run reduction in poverty incidence in Savannakhet is slightly smaller than the reduction in Mukdahan, even though the increase in aggregate real consumption was marginally higher. Within both provinces there is a small increase in measured inequality, which is largest in Savannakhet. The meaning of this result is that the reductions in consumer prices resulting from reduced inter-regional transport costs benefit richer consumers in Savannakhet proportionately more than the poor. Nevertheless, this increase in inequality is relatively small.

Table 15. **Changes in Poverty Incidence and Inequality in the Short Run**

	Mukdahan	**Savannakhet**
Poverty incidence (%)		
Ex ante	14.30	38.50
Ex post	14.26	38.47
Change	–0.04	–0.03
Gini index (%)		
Ex ante	47.829	34.017
Ex post	47.830	34.021
Change	0.001	0.004

Source: Authors' calculations.

D. Results: Long Run

The long-run results differ from the short-run results because of greater mobility of factors of production, hence the greater scope for economic adjustment to the reduction in inter-regional transport costs. The difference between these two sets of results indicates that greater factor mobility makes a large contribution to the overall impact of reduced transport costs (Table 16). The absolute gain in welfare (aggregate real consumption) that arises in the long run is larger than the short-run impact (shown in Table 10 above) by a factor of 22 in Mukdahan and 28 in Savannakhet, while both the absolute and proportional gains in welfare are still considerably larger in Savannakhet. Regional exports increase in both, but especially in Mukdahan. As before, the increase in regional trade (both exports and imports) is partly at the expense of a decline in trade with the rest of the world (Tables 17 and 18).

Table 16. **Summary of Macroeconomic Results in the Long Run**

	Percentage Change		**Absolute Change (US$'000)**	
	Mukdahan	**Savannakhet**	**Mukdahan**	**Savannakhet**
Real GPP	1.305	2.337	3,029.33	7,906.05
Real household consumption	1.643	2.547	2,846.08	7,389.16
Real export to ROW	1.283	3.129	1,164.28	2,405.25
Real import from ROW	0.988	1.335	1,338.59	2,051.81
Sales to other region	13.179	21.694	842.27	433.95
Purchases from other region	21.694	13.179	433.95	842.27

GPP = gross provincial product; ROW = rest of the world.
Note: ROW does not include the partner region (Mukdahan or Savannakhet).
Source: Authors' calculations.

Table 17. **Change in Composition of Nominal GPP in the Long Run**

	Percentage Change		**Absolute Change (US$'000)**	
	Mukdahan	**Savannakhet**	**Mukdahan**	**Savannakhet**
GPP	1.219	2.086	2,831.05	7,067.54
Household consumption	1.591	2.363	2,756.98	6,862.11
Investment	–0.039	–0.146	–22.43	–158.94
Government spending	–0.067	–0.146	–24.38	–13.11
Stocks	2.644	3.189	120.86	376.83
Non-regional exports	1.218	2.970	1,106.06	2,284.99
Non-regional imports (–)	–0.988	–1.335	–1,338.59	–2,051.81
Regional exports	13.126	21.529	839.05	430.96
Regional imports (–)	–21.529	–13.126	–430.96	–839.05
Net margin	–49.234	–49.234	–175.56	175.56

GPP = gross provincial product.
Note: Imports enter the table with a negative sign because of the national accounting identity that GPP is equal to consumption plus investment plus government spending plus exports minus imports. Thus, the table indicates that non-regional imports (row 7) and regional imports (row 9) increase in both regions.
Source: Authors' calculations.

Table 18. **Composition of Changes in Inter-Regional Trade in the Long Run**

	Percentage Change		Absolute Change (US$'000)	
	Mukdahan	**Savannakhet**	**Mukdahan**	**Savannakhet**
Crops	11.539	10.790	0.08	36.92
Livestock	11.515	11.245	1.59	2.19
Forestry	11.486	0.000	0.52	0.00
Mining	0.000	10.176	0.00	0.09
Food	11.553	10.920	368.74	0.32
Textiles	16.491	11.112	241.48	2.51
Wood and paper	11.423	24.393	1.93	391.19
Chemicals	18.546	0.000	18.47	0.00
Minerals	13.405	0.000	133.87	0.00
Machinery	11.064	0.000	61.14	0.00
Transport	29.621	10.443	14.67	1.04

Note: Categories for which all entries are zero have been deleted for brevity. For the full list of all 20 industries, see Table 14.
Source: Authors' calculations.

The industrial composition of the increase in inter-regional exports (Table 19) is similar to the short-run case (food and textiles from Mukdahan, and wood and paper and crops from Savannakhet), but the absolute magnitudes are larger. Within both regions, the composition of output moves toward food and textiles and in Savannakhet it moves toward the wood and paper sector and away from mining (Table 20).

Table 19. **Exports to the Rest of the World in the Long Run**

	Percentage Change		Absolute Change (US$'000)	
	Mukdahan	**Savannakhet**	**Mukdahan**	**Savannakhet**
Crops	1.267	2.794	339.87	125.15
Livestock	0.924	3.220	0.02	385.60
Forestry	0.932	0.000	0.36	0.00
Mining	0.913	1.810	23.89	600.46
Food	1.107	4.606	169.80	817.11
Textiles	0.985	27.572	74.52	289.99
Wood and paper	124.355	2.850	127.81	55.22
Chemicals	0.678	52.743	0.00	0.00
Minerals	0.924	53.852	0.86	0.00
Machinery	0.404	8.092	0.00	0.00
Other manufacturing	0.000	2.253	0.00	0.00
Electricity and water	0.721	2.682	0.00	0.00
Construction	0.853	3.287	1.23	0.00
Transport	1.330	50.180	9.74	17.20
Telecom	1.000	2.841	1.61	14.67
Trade	1.028	2.597	7.06	16.51
Banking	2.747	2.871	0.00	0.00
Real estate	0.987	2.973	0.00	0.00
Public sector	1.346	2.973	0.00	0.00
Personal services	1.125	2.081	410.69	86.72

Source: Authors' calculations.

Table 20. **Changes in Industry Outputs in the Long Run**

	Percentage Change		Absolute Change (US$'000)	
	Mukdahan	**Savannakhet**	**Mukdahan**	**Savannakhet**
Crops	1.484	2.727	932.69	1,306.00
Livestock	1.866	2.677	287.30	3,169.55
Forestry	1.545	2.620	5.44	178.27
Mining	1.027	1.800	42.96	563.74
Food	1.953	2.671	1,898.27	5,196.32
Textiles	3.291	7.567	384.19	366.67
Wood and paper	14.476	4.950	23.42	535.27
Chemicals	4.193	8.984	25.64	8.39
Minerals	12.301	4.391	83.60	27.13
Machinery	5.654	2.183	63.93	156.73
Other manufacturing	0.000	2.398	0.00	103.88
Electricity and water	1.663	2.696	113.50	127.73
Construction	0.020	0.071	7.64	57.43
Transport	–0.884	–9.346	–103.86	–62.71
Telecom	1.491	2.822	133.33	18.10
Trade	1.216	2.187	577.10	1,116.52
Banking	1.579	2.133	217.60	129.85
Real estate	1.627	2.471	225.93	239.98
Public sector	0.000	0.856	0.00	107.54
Personal services	1.247	2.286	1,120.87	1,199.36

Source: Authors' calculations.

Long-run reductions in poverty incidence are summarized in Table 21 and the method of estimation is illustrated in Figures 2 and 3. The vertical lines in the two figures depict the official poverty lines in these two provinces, respectively. The solid and dashed lines show the cumulative density functions of household real expenditures, deflated by household-specific consumer price indices, before the bridge (ex ante), as captured by the observed survey data (solid line), and the simulated (ex post) distribution with the bridge (dashed line). These two distributions correspond to the sorted ex ante distribution y_c and the re-sorted ex post distribution y_c^{**}, described in Section VI. The intersection of each of these cumulative density functions with the poverty line indicates poverty incidence. The difference between the two is the impact of the bridge.

The estimated long-run reductions in poverty are larger than the short-run reductions (Table 15 above) by a factor of 21 in the case of Mukdahan and 43 in the case of Savannakhet. Small increases in measured inequality occur in both regions. The effect in Mukdahan is similar to the short-run effect but the effect in Savannakhet is considerably smaller than the short-run effect. As noted above, the short-run effects are dominated by changes in consumer prices resulting from the reduced transport costs, but the long-run effects are dominated by supply-side adjustments. In Savannakhet, these short-run consumer price benefits accrue disproportionately to richer households but the long-run supply-side benefits are more equally distributed, approximately erasing the increase in inequality that occurs in the short run.

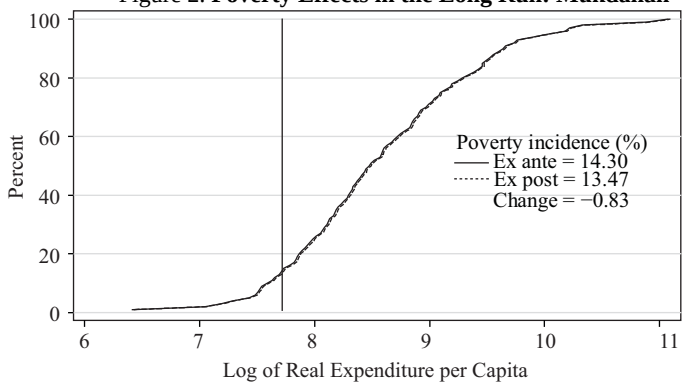
The increased mobility of factors of production that characterizes the long-run closure facilitates economic adjustment to the changed transport cost structure and this response accounts for most of the regional economic benefits from the bridge and associated infrastructure. That is, reduced consumer prices made possible by reduced transport costs are not the principle source of benefit, because these benefits are captured by both the short-run and long-run simulations. Economic adjustment on the supply side in response to the reduced transport costs is a far more important source of gain, as captured by the long-run results.

Table 21. **Changes in Poverty Incidence and Inequality in the Long Run**

	Mukdahan	**Savannakhet**
Poverty incidence (%)		
Ex ante	14.30	38.50
Ex post	13.47	37.20
Change	–0.83	–1.30
Gini index (%)		
Ex ante	47.829	34.017
Ex post	47.830	34.018
Change	0.001	0.001

Source: Authors' calculations.

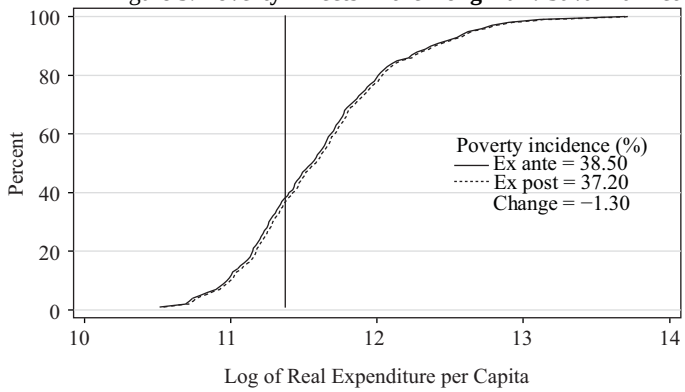
Figure 2. **Poverty Effects in the Long Run: Mukdahan**



Notes: The vertical line represents the official poverty line in Mukdahan Province. The horizontal axis is the logarithm of baht per month in 2005 prices.

Source: Authors' calculations, using data from Socio-economic Survey 2005, National Statistical Office, Bangkok.

Figure 3. **Poverty Effects in the Long Run: Savannakhet**



Note: The vertical line represents the official poverty line in Savannakhet Province. The horizontal axis is the logarithm of kip per month in 2002 prices.

Source: Authors' calculations, using data from Lao Expenditure and Consumption Survey, 2002–03, National Statistical Centre, Vientiane.

VIII. CONCLUSION

This study has used a general equilibrium framework to study the regional economic effects of infrastructure improvements designed to reduce the costs of inter-regional trade. The results suggest that in the short run, the kind of transport cost reductions consistent with improvement of inter-regional transport facilities will produce a modest increase in inter-regional trade volumes in both directions. This coincides with a small increase in real consumption in both regions and correspondingly small reductions in poverty incidence. Over a longer period, the benefits to both regions, including reductions in poverty incidence, are much larger, as investors respond to the changed structure of incentives with new capital investments, and as workers move to regions of greater return to their labor. These benefits are significant in both regions. The results therefore do not confirm the common presumption that the local benefits from cross-border infrastructure projects occur only, or overwhelmingly, in the richer region, which in this case is Mukdahan Province of Thailand. The estimated long-run benefits are also significant in the poorer region, Savannakhet Province of the Lao PDR.

The analysis presented in this study does not cover all possible benefits from the construction of the bridge. It concentrates on the impact in the two provinces adjacent to the bridge itself. Broader economic benefits to Thailand and the Lao PDR, as well as benefits to neighboring countries, are important but are not quantified by this study. The development of entirely new industries not represented in the existing input–output tables is a further possible real world development that is not captured by this analysis. Moreover, the analysis focuses on reduced transport costs in the movement of goods. But reduced costs in the

movement of people, especially in the form of time saved in crossing the river, may be important as well. For example, the bridge seems to have facilitated two-way tourist movement between Thailand and Viet Nam, crossing through the Lao PDR, and presumably generating some economic benefits there. These benefits are not captured by the analysis.

The objective of this study was in part methodological. The results suggest that general equilibrium modeling is a promising methodology for estimating the possible impacts of infrastructure investments, including their distributional effects. The basic methodology of general equilibrium modeling is well established, although new developments are continuously being created. However, the application of this type of analysis to the estimation of the impact of large investment projects is in its infancy. The present study is only a first step, and more work is required to achieve the most operationally useful modeling approaches for practical application.

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