

Impact of Cross-border Road Infrastructure on Trade and Investment in the Greater Mekong Subregion

Christopher Edmonds^a and Manabu Fujimura^b

^a Rural Development Economist, East Asia Regional Department, Asian Development Bank, and Adjunct Fellow, East-West Center.

^b Professor, Department of Economics, Aoyama Gakuin University.

Summary

This paper investigates the impact of cross-border road infrastructure on trade and foreign direct investment in the Greater Mekong Subregion using panel data from 1981 to 2003. Empirical analysis based on a gravity-model approach suggests that the development of cross-border road infrastructure has had a positive effect on intra-regional trade in major commodities with its elasticity in the range of 0.6 to 2.3. When the impact of domestic road infrastructure is assessed separately, it has been associated with increased trade. When cross-border and domestic road infrastructures are considered together, the former has had a positive and the latter has had a negative association, respectively, with trade. Results regarding the impact of road infrastructure on foreign direct investment (FDI) flows are ambiguous, although data limitations appear to have been contributed to the poor performance of these estimates.

The authors thank the Asian Development Bank Institute (ADBI) and the East-West Center for their support in the research for this paper. They gratefully acknowledge a valuable support in data collection provided by Mr. Magnus Andersson, Director of Center for Asian Studies, Stockholm School of Economics.

I. INTRODUCTION

This paper investigates the impact of cross-border road infrastructure on the economies of the Greater Mekong Sub-region (GMS).¹ Cross-border and domestic road infrastructure together can reduce transport costs and lead directly to increased trade. Reduced transport costs can also raise indirectly foreign direct investment (FDI) by reducing transaction costs involved in intra-firm vertical integration structured to exploit varied comparative

advantages across countries. Increases in FDI, in turn, can further increase regional trade, and add to the direct effect of reduced transport costs achieved through improvements in the road infrastructure in border areas. If true, this would define a virtuous cycle of cross-border infrastructure development, trade, and investment that fosters increased trade and economic growth. Despite the many initiatives of economic integration in practice in the GMS, there has been only limited empirical research (e.g., Poncet [2006]), and to our knowledge, none on the role of cross-border road infrastructure. This paper helps fill this gap.²

We estimate trade creation and investment facilitation effects of cross-border road infrastructure in the GMS through econometric examination of historical data. In particular, following the approach of Limao and Venables [2001], we estimate gravity model equations for trade and FDI flows between each pair of the six (pre-2005) GMS economies. The gravity approach has been widely applied in empirical studies of bilateral trade since its introduction by Tinbergen [1962] and Poyhonen [1963]. "In most cases, the basic gravity model has been employed to capture statistically the bulk of trade variation to discern the marginal explanatory power of free trade pacts and/or exchange rate variability with an aim to test one theory or another" (Bergstrand [1998] pp. 27-28). Our principal interest in applying the gravity model in this paper is to use it to establish expected levels of trade between GMS economies from which we can quantify the marginal or incremental effect of cross-border (border-area) road infrastructure on trade in GMS relative to the effect of general domestic (non-border area) road infrastructure.

Despite data limitations associated with the relatively small number of economies included in our analysis and shortcomings in reliable reporting of FDI and other key data in some of the GMS economies, our estimates are able to explain much of the variation in trade flows. Estimates are less successful in explaining FDI flows. Our results show that the quality of road infrastructure in the border area between economies has a positive and statistically significant relationship with trade flows between them, and that this relationship is particularly strong when both cross-border and general domestic road infrastructure are included in the estimates. This result is important to policy as governments and international development organizations seek effective mechanisms for promoting regional trade and broader economic growth in the GMS.

Section II of the paper discusses the relevant literature we reviewed and Section III sets out the research questions we consider. Section IV presents the analytical approach and estimation models we applied. Section V discusses characteristics of the data we used in our analysis. Section VI presents our estimation procedures and Section VII discusses our results and implications. Finally, Section VIII provides concluding remarks.

II. RELEVANT LITERATURE

This paper draws from two broad strands of recent economic literature. First, the economic geography literature that has flourished since the 1990s and makes increasingly clear the importance of geography in explaining patterns of trade and economic development. For example, access to sea and distance to major markets have been shown to have strong effects on shipping costs, which in turn, strongly influence trade flows in manufactured goods (e.g., Limao and Venables [2001]). Economies suffering multiple geographical handicaps such as landlocked status, an absence of navigable rivers and lakes, or tropical or desert ecology, tend to be among the poorest in the world (e.g., Radelet and Sachs [1998]; Redding and Venables [2004]). These papers have documented a strong negative empirical

relationship between transport costs and economic growth controlling for the other variables expected to influence growth. In the context of the GMS, the relative poverty of Lao PDR has long been understood as at least a partial result of the country's landlocked status and geographic characteristics. Empirical evidence in this literature suggests there is much potential for cross-border road infrastructure and associated institutional arrangements to benefit economies that are not endowed with favorable geographic characteristics.

Second, one branch of the recent trade literature has focused on trade and FDI linkages (the so-called "trade-FDI nexus") in explaining patterns of trade and, ultimately, patterns of economic development. Empirical analyses in the area have found that multinational firms can gain from intra-firm trade by integrating production processes across economies with different areas of comparative advantage. When such gains are present, this reduces tendencies towards production agglomeration, and if the advantages of production integration across economies outweigh those from agglomeration, then reductions in transport costs would make FDI complementary to trade. The literature on the trade-FDI nexus shares an understanding that one of the common threads in the economic successes of the "East Asian Miracle" has been the openness of these economies to FDI and their time-limited and targeted use of protectionist measures, which enabled their economies to overcome late-comer disadvantage and to reap the benefits of learning by doing and network presence in their manufactured exports. Researchers have asserted that in the case of some East Asian economies, this led to a virtuous cycle of increased trade, economic growth, and FDI, and fueled their emergence as export-oriented manufacturing-based economies.³ The experience of East Asian economies and the potential gains from trade (and capital transfers) between economies in the GMS suggest the latter has the potential to benefit from a similar trade-FDI nexus and greater regional economic integration enabled by improved cross-border road infrastructure.

III. RESEARCH QUESTIONS

Our interest extends to a few empirical questions considered to be of importance in the context of ongoing road infrastructure development in the GMS.

- What is the empirical relationship between the level of development of cross-border road infrastructure, and trade and FDI flows between GMS economies, historically?
- Can positive marginal effects of cross-border road infrastructure development on trade flows be found empirically, and if found, what is the magnitude of such effects?
- Has the development of cross-border road infrastructure been associated with increased FDI flows, and if so, to what extent can trade creation be attributed to increased FDI?

IV. ANALYTICAL APPROACH AND ESTIMATION MODELS

Our analytical approach is adapted from Limao and Venables [2001] and applies a gravity model to predict bilateral trade and FDI flows for each pair of GMS economies. However, departing from Limao and Venables, we omit estimation of an explicit transport cost equation due to data limitations. The lack of reliable measures of transport costs within the GMS and their proxies is discussed in Section V. Instead, we proceed by using an instrument for transport costs (distance) and include this directly in our trade and FDI equations. Also, departing from the existing empirical literature on the trade-FDI nexus, data limitations prevented us from estimating indirect impacts that come through trade and

FDI.⁴ Estimation parameters of our particular interest are the responses of trade and FDI to various transport cost factors including cross-border road infrastructure.⁵ Accordingly, our empirical analysis centers on the following two functional relationships:

$$1. \text{ Trade equation: } X_{ij} = X(E_i, E_j, R_{ij}, R_{ji}, D_{ij}, F_{ij}, \omega_{ij})$$

- X_{ij} : exports of economy i to economy j ,
- E_i, E_j : vector of characteristics of economy i (j) related to trade such as economy size (GDP), population, land area, trade barriers, and other variables typically used in gravity model estimates,
- R_{ij}, R_{ji} : vector of variables measuring road infrastructure in border areas and non-border (domestic) areas in economy i (j) with respect to economy j (i),
- D_{ij} : distance between economies i and j ,
- F_{ij} : economy i 's foreign direct investment from economy j , and
- ω_{ij} : other factors not accounted for (model error).

The trade equation incorporates standard variables used in gravity models plus variables of our particular interest in this research (i.e., measures of cross-border and domestic road infrastructure, and FDI from the trading partners). Economy's GDP is considered a key variable in the base gravity model because larger economies are expected to engage in greater trade (*ceteris paribus*). Trade is expected to be positively influenced by the economic mass of the trading partners and negatively affected by the distance between them. Our focus in this paper is on how road infrastructure is related to bilateral trade in the GMS. Specifically, we envision that bilateral trade between GMS economies is a function of the quality of road infrastructure generally in each economy and particularly the quality of road infrastructure in border areas. Other factors seen as important in driving levels of bilateral trade are differences in price levels between economies, tariff rates, and a broad characterization of the export/import environment in the economies.

Gravity models are often estimated with a few other variables to characterize the geographic characteristics and proximity of economies besides distance (e.g., sharing land border, landlocked status, small island status) or cultural-historical ties (e.g., shared language, dominance by common colonial power), however, these variables are not included in our estimates because there is insufficient heterogeneity in these variables and insufficient degrees of freedom in our small sample of GMS economies.

$$2. \text{ FDI equation: } F_{ij} = F(E_i, E_j, R_{ij}, R_{ji}, D_{ij}, X_{ij}, z_i, \varepsilon_{ij})$$

- F_{ij} : economy i 's foreign direct investment received from economy j ,
- $E_i, E_j, R_{ij}, R_{ji}, D_{ij}, X_{ij}$: same as in the trade equation,
- z_i : vector of other characteristics related to economy i 's investment climate, and
- ε_{ij} : other factors not accounted for (model error).

The FDI equation specifies that FDI flows are determined by several factors common to the trade equation (e.g., economy size and resources, inflation rate, tariff rates). Of our particular interest, again, is in the relative marginal contributions of cross-border and domestic road infrastructure to FDI flows between the GMS economies. In addition, FDI is viewed as being influenced by various other factors related to the investment climate of the recipient economy.

Following the empirical approach common to gravity models of trade, our base models use two parametric specifications for the above functional relationships:

$$X_{ijt} = A Y_{it}^{\alpha_E} Y_{jt}^{\alpha_M} H_i^{\beta_E} H_j^{\beta_M} N_{it}^{\gamma_E} N_{jt}^{\gamma_M} D_{ij}^{\theta} (\varepsilon_{ijt} u_{ij})$$

$$\text{or } X_{ijt} = A (Y_{it} Y_{jt})^{\alpha} (H_i H_j)^{\beta} (N_{it} N_{jt})^{\gamma} D_{ij}^{\theta} (\varepsilon_{ijt} u_{ij})$$

where X_{ijt} : are exports from economy i to economy j in time t ,
 Y_{it} , Y_{jt} : are the gross domestic products of economies i and j in year t ,
 H_i , H_j : are the geographic sizes of economies i and j ,
 N_{it} , N_{jt} : are the populations of economies i and j in year t ,
 D_{ij} : is the distance between (the capitals of) economies i and j ,
 ε_{ijt} : is the regular error term,
 u_{ij} : is an error component specific to economy-pair i - j ,
 A : is a constant,
with the following signs generally expected for the estimation parameters:

$$\alpha_E, \alpha_M, \alpha, \beta_E, \beta_M, \beta > 0; \text{ and } \gamma_E, \gamma_M, \gamma, \theta < 0.$$

In logarithmic form, we have:

$$\ln X_{ijt} = \ln A + \alpha_E \ln Y_{it} + \alpha_M \ln Y_{jt} + \beta_E \ln H_i + \beta_M \ln H_j + \gamma_E \ln N_{it} + \gamma_M \ln N_{jt} + \theta \ln D_{ij} + \ln \varepsilon_{ijt} + \ln u_{ij}$$

$$\text{or } \ln X_{ijt} = \ln A + \alpha (\ln Y_{it} + \ln Y_{jt}) + \beta (\ln H_i + \ln H_j) + \gamma (\ln N_{it} + \ln N_{jt}) + \theta \ln D_{ij} + \ln \varepsilon_{ijt} + \ln u_{ij}$$

(The FDI equation takes the same form and is not presented here to save space).

The first specification takes a Cobb-Douglas form in which the influences of each trading partner's economic size, population, and geographic area enter the equation separately. The second specification enters the characteristics of economies i and j as products, following more closely the Newtonian form of the gravity equation. The advantage of the first specification is that it allows examination of the effects of variables between exporting and importing economies separately.⁶ The second specification offers a more straightforward interpretation and has the additional advantage of reducing the number of estimation parameters, which is helpful when sample size is relatively limited as in our dataset. Using these specifications as our base models, we add variables for road infrastructure and obtain estimates that control for other standard variables treated in the gravity model.

Before discussing the dataset used in our analysis, some comments regarding potential problems with endogeneity between trade flows and the other variables in the model seem warranted. Endogeneity between trade flows and GDP, and between overland trade flows and the quality of road infrastructure in the border areas -in particular- are of concern in this regard. With respect to the former, we note that the widespread use of GDP as a regressor in the vast gravity model literature. Moreover, we use a measure of major goods traded over land (to be explained later) in addition to total bilateral trade as our dependent variable, which would have only a limited endogeneity problem since major goods traded over land represents a smaller share of GDP. Were it the case that cross-border road infrastructure is developed in response to increased demand by traders, then endogeneity between trade and cross border road infrastructure would be a problem. However, the significant lead time required before a planned road is constructed and is available for transporting goods supports treating the extent of road infrastructure as an exogenous variable.

V. DATA

Our dataset tracks trade and other variables for each pair of GMS economies over the period of 1981 to 2003. In all, 30 economy pairs can be formed across the 6 GMS economies (i.e., Cambodia-Laos, Cambodia-Myanmar, (...), Yunnan-Thailand and Yunnan-Vietnam). Table 1 summarizes descriptive statistics from the dataset along with details on the data sources and definitions of variables. In the table, "between n" reports the number of reporting economy pairs (maximum 30), "within T(-bar)" the number of data years (maximum 23 years), and "overall N" the total number of observations (maximum $30 \times 23 = 690$).

Due to the relatively small number of GMS economies and limited number of years for which most data are available, missing data problems were widespread and created challenges in estimating our models. This is particularly true for data during the initial years of our panel, when many of the GMS economies were suffering prolonged periods of conflict or social unrest and did not have well-established national statistical services. In the remainder of this section we discuss details on data collection and the measures we used for key variables.

TRANSPORT COST

This study required information on overland transport costs because of our focus on road infrastructure. However, gathering reliable measures for these proved difficult. Past studies, including Limao and Venables [2001], used directly observed transport costs data collected from shipping and logistics companies and they mainly capture the costs of transport by sea. We were not able to find reasonable data directly representing observed transport costs overland in the GMS. Then we considered using a commonly employed proxy for transport costs: the ratio of Cost, Insurance, and Freight (CIF) and Free on Board (FOB) prices. The CIF/FOB ratio between two economies provides a proxy for average costs of transporting goods between them weighted by the value of the goods being traded.⁷ In the case of the GMS, however, collecting panel data for CIF/FOB proved impractical because: (i) the trade authorities for most GMS economies record export values in FOB only and import values in CIF only; and (ii) FOB import values reported in balance of payment statistics are available only at the economy-aggregate level, but not by individual trading partner. An alternative to finding FOB import values would be to assume the FOB export values equal the FOB import values for corresponding trade partners; however, analysis of these data revealed large discrepancies between the recorded values for exporters and those for corresponding importers. Problems of missing or unreliable trade data reported in GMS economies with weak statistical capacity such as Cambodia, Lao PDR, and Myanmar lead international trade databases including the International Monetary Fund's (IMF) *Direction of Trade Statistics* (DOTS) to adjust the data for these economies based on data of their trading partners such as China and Thailand (for example, in a number of cases, it appeared that an assumed CIF/FOB ratio of 1.08 was used). Other data sources and adjustments to derive transport cost measures were tried, but none proved reliable ultimately. Due to these data problems with transport costs, we had to forgo the estimation of the effects of road infrastructure in two steps -first on transport costs, and then second on trade flows- and instead estimate the determinants of trade (and FDI) flows in one step as described in Section IV.

Following common practice in gravity model estimation, the distance between capitals (approximate direct point-to-point distances) is used as proxy variables for transport costs.⁸ Estimation results presented in Section VII are based on these data. However, in order to check the robustness of our results, changes in this proxy are tested

using information on air freight charges collected from GMS shipping firms, which was the only measure of transport costs we could identify that was generally available for international transport costs between the GMS countries. Efforts to gather information on the cost of shipping goods between the countries' capitals via roads or waterways were unsuccessful, which may be a reflection of difficulty of transporting goods between cities in the GMS. Table 2 summarizes these data.

TRADE FLOWS

We employ two measures of trade flows: one based on total bilateral trade reported in the IMF-DOTS database (except for Yunnan Province for which data are taken from Yunnan Statistical Yearbook), and the other based on "major exports" transported via land or river. For the latter measure, the selection of the representative commodities relied on customs data available at selected international crossing points (including river ports) in the GMS. Up to five commodities defined at the four digit level in the UN Harmonized System of Product Categories that are considered largely transported via land (or ferry, where river transport dominates) are identified and their export values reported in the UNCOMTRADE database are summed to form the measure of major exports via land.⁹ Use of this measure is preferred to the use of total bilateral trade because cross-border road infrastructure is expected to be more important in determining the volume of overland trade flows than total trade, which includes ocean-bound trade and is influenced by a greater variety of factors. However, the use of the preferred measure comes at the cost of data scarcity and there is some unavoidable subjectivity in the selection of major goods due to sketchiness of customs data at overland points of entry. Therefore, the use of the total bilateral trade serves as a check on the sensitivity of estimates depending on the choice of the trade measures, and it can also gauge the effect of more limited sample size on estimates despite the presumably weaker relationship between total trade and cross-border road infrastructure.

One last issue concerning the data used in this study concerns the problem of undocumented trade/smuggling between GMS economies. The limited evidence available regarding the magnitude of smuggling suggests that a significant portion of intra-GMS trade goes unrecorded by government officials. Estimates of the value of smuggled goods generally fall in the broad range of 30 to 50 percent of the value of the recorded trade (ADB [2004] p.14). However, for the purpose of this paper, we maintain that omission of the value of unrecorded trade is unlikely to significantly influence estimates due to our focus on international crossing points-as opposed to local border crossing points-in deriving the measure of cross-border road infrastructure.¹⁰

ROAD INFRASTRUCTURE

We construct two separate measures for road infrastructure based on road density in GMS economies: one characterizing road density in border areas and the other characterizing road density in non-border areas.¹¹ In this paper "cross-border road infrastructure" is represented by the density of paved roads in the provinces (for Cambodia, Lao PDR, Thailand, and Vietnam), states (for Myanmar) or districts (for Yunnan Province) containing international crossing point(s) to the corresponding GMS pair. "Domestic road infrastructure" is represented by the density of paved roads in the provinces, states or districts that do not border any economy. Figure 1 displays the GMS road network and border crossing points referenced in our dataset while Table 3 gives the names of these

locations. For example, cross-border road infrastructure for Cambodia as an exporter and Lao PDR as an importer is represented by the road density in Stung Treng Province of Cambodia and Champassack Province of Lao PDR, respectively. In Tables 3 and Figure 1, these variables are represented by "cross-border roads exporter" and "cross-border roads importer," respectively. Similarly the domestic road infrastructure in this case is represented by road density of all the other provinces in these economies and they are represented by "domestic roads exporter" and "domestic roads importer," respectively. Road density is calculated by dividing the total road length in border (non-border) provinces by the total area of the corresponding provinces, states, or districts, with adjustments in a few cases where disaggregated road inventory data are unavailable.¹²

VI. ESTIMATION PROCEDURES

Estimates are carried out using estimators suitable to the panel structure of our data. By panel, we refer to the fact that data consists of variables covering the cross-section of GMS economies over time, which raises concerns of serial correlation in estimation residuals.¹³ Depending upon the results of Hausman and Breusch-Pagan Lagrange Multiplier tests, either the random effects estimator or the robust ordinary least squares (OLS) estimator is applied. Robust OLS is the regular OLS estimator with a Huber-White correction, which takes into account the panel-nature of the data in recalculating standard errors. The fixed effects estimator cannot be applied since key variables of concern (e.g., distances, land areas) are fixed over time. The Hausman test indicates whether the fixed or random effects approach is appropriate by testing for omitted variables. A significant result from the Hausman test indicates that strong parametric assumptions of the random effects estimators are not met so this estimator is not suitable. In such cases, we use the robust OLS estimator despite its reduced efficiency. The Breusch-Pagan test evaluates the significance of random effects versus a regular OLS estimator by examining the statistical significance of economy-pair-specific error terms included in the random effects estimator. A significant result from the Breusch-Pagan test implies that the random effects estimator should be used.

Coefficient estimates in random effects estimation reflect a weighted average of the cross-sectional and time-series association between the dependent and independent variables included, with the weighting indicated by the estimation parameter Rho. The statistical significance of coefficient estimates is tested using a z-test that is functionally equivalent to a standard t-test applied in OLS regression. The overall statistical significance of the estimation models is tested using the Wald Chi-square test, which indicates the probability of a false rejection of the null hypotheses that the model has no explanatory power over the dependent variable.

Finally, coefficient estimates in all estimation models can be interpreted as elasticities because they are estimated in logarithmic form.

VII. ESTIMATION RESULTS

Table 4 presents estimation results on total exports between GMS economies. Seven variant specifications of the model are reported. As explained above, we used two sets of data for the "distance" variable: actual distance (in kilometers) between capital cities, and air freight fees between the corresponding cities. The results using the air freight cost data are reported in Appendix Table 1. All models yield coefficient estimates that

are largely consistent with expectations (e.g., a negative association with distance and a positive association with economic size), and conform to gravity model results in several recent papers.¹⁴ All the models except Model 7 show overall goodness of fit with R-squared coefficients in the range of 44 to 63 percent (24 to 60 percent, when shipping cost used in place of distance). They are all highly statistically significant according to results of F-test (robust OLS) or Wald Chi-square test (random effects). The results of Hausman test indicate that the robust OLS estimator should be used for all models except Model 3.

The overall results suggest that the gravity model approach provides a sound basis upon which we can judge the marginal effect of additional variables on the level of trade. In particular, Model 1 includes only the gravity model base variables with exporting and importing economies separated. The coefficient estimates have the expected signs and significance, so endorse application of the gravity model to analyze trade flows in the GMS.

In Model 2, cross-border road infrastructure is found to have a positive and statistically significant association with total exports on both the exporter's and importer's sides of the border. According to this estimate, a one percent increase in the stock of roads on each side of the border area are associated with 1.2 to 1.3 and 1.7 to 1.8 percent increases in total trade between the importing and exporting economies, respectively. Model 3 adds measures of domestic road infrastructure, alone, to the base gravity model, and finds a positive but statistically insignificant association between total trade and domestic roads.

Models 4, 5, and 6 add both cross-border and domestic road infrastructure to the base gravity model estimates of total trade. While coefficient estimates based on the distance data for transport proxy are positive and statistically significant only on exporter's side, those based on the freight costs are positive and statistically significant on both exporter's and importer's sides. This suggests cross-border road infrastructure in the GMS has a positive association with the volume of intra-GMS trade. In contrast, domestic roads are estimated to have a negative and statistically significant association with total trade in many model estimates. Compared with models in which only cross-border road infrastructure is included in the explanatory variables, models in which both cross-border and domestic road infrastructure variables are included obtained larger coefficient estimates for the cross-border road infrastructure. A likely explanation for this is that these are artifacts of high covariance between our measures of cross border and domestic road infrastructure measures.¹⁵ The magnitudes of the trade effects estimated for importer's cross-border and domestic road infrastructure appear unreasonably large given the presumably smaller influence they would have on aggregate trade relative to their influence on major overland trades. But the results could also be explained if our road measures were capturing broader policies determining trade orientation/openness. This would occur if economies more oriented towards foreign trade tended to make greater investments in cross-border infrastructure.

If, as indicated by the results in Models 4 through 6, cross-border and domestic road infrastructure play non-complementary roles in promoting regional trade in the GMS, regional integration would require strategic shifts in road investments toward border areas.

Model 6 includes the average weighted tariff rate of the importer as an explanatory variable. However, this is found not to have a statistically significant effect on trade. Possible explanations for this are that tariff rates averaged across all goods and trading partners poorly reflect the tariff rates between particular GMS economies or that non-tariff barriers are of greater importance than tariff levels in determining trade. Lastly, Model 7 estimates the relationship between FDI on trade by adding measures of bilateral FDI flows to the base gravity model, and finds no statistically significant relation between the two.¹⁶

Comparing results from estimates using distance and those using air freight costs, the former yields more consistent results in line with past gravity model estimations, but both series indicate there is a positive association between cross-border road infrastructure and trade flows that is robust to the specification used for the transport cost proxy.

Table 5 (and Appendix Table 2) present results for the determinants of the major exports over land between GMS economies. Models 8 to 15 report estimated R^2 measures ranging between 47 percent (Model 8) and 74 percent (Model 12), and all models are highly statistically significant as indicated by the results of F-test or Wald Chi-square test.¹⁷ Based on the results of Hausman test, all models except models 9 and 10 use the robust OLS estimator.

Gravity model estimates carried out using the major export measures are less successful in explaining past trade than the estimates using the total export measures. The coefficient estimates on the base variables of the gravity model, except for GDP, failed to yield expected signs and statistical significance consistently. The contrast between the results from estimates using total and major export measures could be due to the limited explanatory power of the gravity model for the latter (i.e., major goods transported over land in the GMS) or to the much reduced sample available in the latter estimates. The distance variable shows either an insignificant or a positive influence on major exports, which is counter to the expectation from gravity model. Perhaps, distance between capitals is a poor indicator for the relevant distance in determining overland trade flows between GMS economies, which would be the case if overland trade tended to focus on markets besides the capital city (e.g., regional markets closer to border areas).

When the cross-border road infrastructure variable is added separately to base variables of the gravity model (as in models 9 through 12), we find a positive and statistically significant association with trade levels for both exporter's and importer's sides of cross-border roads. Estimated trade elasticities with respect to cross-border roads range between 0.635 and 2.256 (Model 9, under specification using distance and freight costs, respectively). The estimated elasticities are generally larger for exporter's side except in the case of model 10, and are relatively stable across the various model specifications estimated. As noted above for the case of the total exports estimates, using distance or air freight costs as proxies for transport costs do not significantly change results in terms of the positive and statistically significant association obtained between cross-border road infrastructure and trade flows.

The trade elasticities with respect to cross-border road infrastructure appear more reasonable in the major export estimates than in the estimate of total exports, which would follow from the expected closer relation between cross-border transport infrastructure and trade in goods selected based on their importance to overland trade as opposed to total trade (which relies more heavily on sea shipment).

Model 13 shows that when our measure of domestic road infrastructure is added separately to the base gravity model, it alone has a significant positive association with the level of major exports -with a elasticity of about 1 for both the exporter and importer. Paralleling our finding from the estimates of total trade (Model 14), when both cross-border and domestic road infrastructure measures are included in the model, we find that cross border roads and domestic roads have non-complementary contributions to intra-GMS major exports. This could imply that domestic road infrastructure -when separated from roads in frontier areas- mainly promotes the integration of domestic markets and diverts economic activities away from trade in major goods across GMS economies.

Another relationship of our interest is how FDI flows between GMS economies influence trade levels. Model 15 adds a measured bilateral FDI to the base gravity model and suggests that importer-to-exporter FDI flow has a small (0.095 to 0.098) but statistically significant association with major exports, but that exporter-to-importer FDI flow has no significant effect. This provides some evidence of a positive trade-FDI nexus in which FDI contributes to export growth from the FDI-recipient economies, and would be consistent with the movement of export-oriented assembly and resource extraction activities. Lastly, the result from Model 12 indicates that tariff barriers have no discernible influence on major exports, which was also the case in total exports estimates.

Finally, we are also interested in examining the determinants of FDI flows between GMS economies - particularly the relationship between FDI, trade flows, and development of road infrastructure. Table 6 summarizes FDI inflow estimation results. In general, the gravity model performed poorly in explaining regional FDI flows, although, admittedly, our dataset on FDI flows was small. Calculated R^2 statistics for the models were fairly low, ranging between 0.37 and 0.41, but all models were statistically significant according to F-tests. Few variables except GDP were found to have significant associations with FDI flows. Cross-border road infrastructure was estimated to have a positive but not statistically significant association with FDI in most models, while domestic road infrastructure was found to have a negative but again statistically insignificant association.

VIII. CONCLUSIONS

This paper investigates the impact of cross-border and domestic road infrastructure on trade and FDI flows in the GMS during the past two decades. The theoretical underpinnings of the research draw from the recent economic geography and trade literatures, while the paper's empirical approach is based on a gravity model estimation framework. Our main interest is in the marginal effect of cross-border road infrastructure on trade and FDI when domestic road infrastructure and other controls are taken into account. The most notable findings were:

(i) Economy size appears to be a dominant driver of both trade and FDI, and other base variables of the gravity model generally perform as expected (except for the estimates of FDI flows);

(ii) the elasticity of trade in major exports likely to be transported over land between GMS economies with respect to developments in cross-border road infrastructure is estimated to be in the range of 0.6 to 2.3;

(iii) when the gravity model of total trade is estimated with domestic road infrastructure separately, we find a positive association between the two with an estimated elasticity of about 1.0;

(iv) estimates including measures of both cross-border and domestic road infrastructure show that cross-border roads have a positive association and domestic roads have a negative association with trade flows (both major exports and total trade); and

(v) barriers to trade captured by weighted average tariff rates and a trade environment dummy variable failed to yield significant associations with trade flows, which may suggest a relatively greater impact of unmeasured non-tariff barriers or poor measurement of these proxies for trade policy.

From this analysis, we conclude that the development of cross-border road infrastructure in the GMS has had a positive effect on the regional trade. The result

that cross-border roads have distinct effects from domestic road infrastructure suggests promotion of regional trade may require deliberate policy shifts toward investments in roads in border areas. In this light, cross-border road infrastructure becomes an important part of a broader effort to encourage regional integration to benefit GMS economies that are less endowed with natural seaports such as Lao PDR.

Nonetheless, sample size constraints associated both with the relatively small number of GMS economies and with missing data problems represent serious challenges in carrying out otherwise more comprehensive regression exercises. Our estimates provide little insight into the determinants of FDI flows between GMS economies, although FDI flows are associated at a statistically significant level with slightly higher trade in major exports.

The modeling framework and empirical estimates in this paper provide a useful beginning in efforts to estimate some of the key empirical relationships between road infrastructure development, trade, and FDI in the context of the GMS. While application of the gravity model to intra-GMS FDI flows appears premature, such application could gain relevance in the future as the flow of investments particularly from Thailand and China toward the other GMS economies increase and the data situation in Cambodia, Lao PDR, Myanmar, and Vietnam improves.

Notes

¹ Current members of GMS are Cambodia, Lao PDR, Myanmar, Thailand, Vietnam, Yunnan Province of China, and Guangxi Zhuang Autonomous Region of China. Guangxi Region joined GMS in 2005. Analysis in this paper excluded data for Guangxi Region due to scarcity of detailed data documented (e.g., in Guangxi Statistical Yearbooks), particularly on transport infrastructure. Throughout this paper, we use "economy(ies)" in referring to the members of the GMS.

² The motivation and detailed background of this research are discussed in Fujimura [2004].

³ Trade-FDI nexus in line with the argument here has been well researched in the context of East Asia's economic integration: e.g., Fukao, Ishido and Ito [2003] and Urata [2001].

⁴ The dataset used in this study features too few observations to permit simultaneous estimation of equations (trade and FDI) with a panel structure.

⁵ De [2005] applied a gravity model to Asian countries with transport infrastructure variables and transaction costs among the explanatory variables, but does not distinguish cross-border and domestic transport infrastructure as such.

⁶ However, caution is warranted in interpreting results when asymmetric coefficients for exporting and importing economies are obtained, since these may to a considerable extent be driven by imbalance in the panel.

⁷ $CIF = FOB + \text{freight forwarding charge} + \text{insurance premium}$. To the extent that insurance premiums are similar for goods transported between various GMS markets, the CIF/FOB ratio would provide a good measure of transport costs.

⁸ Capital cities are used except in the case of Cambodia-Vietnam and Thailand-Vietnam trade, where Ho Chi Minh City is used in preference to Hanoi due to that city's prominence as a trade center.

⁹ For example, for major exports from Lao PDR to Thailand the commodities selected (based on goods transit reported at selected border crossing customs stations in 2004) were: HS2483 (wood of non-coniferous species), HS2472 (sawn logs and veneer logs of non-coniferous species), HS0011 (animals of bovine species), HS2876 (tin ores and concentrates), and HS2842 (wood of coniferous species).

¹⁰ A number of other points can be offered with respect to the issue of unmeasured trade within the GMS and its impact on our findings. Improvement in the availability and quality of roads at borders may reduce incentives for smuggling by increasing relative cost of transport via undocumented channels (by making transport via primary roads through international crossing relatively more cost-efficient *vis-à-vis* smuggler routes) and by capacitating customs enforcement. Also, to the extent that major international roads are used by smugglers, estimates of trade effects of cross-border road improvement

will underestimate true positive effect of the road on trade, so examining official trade figures would offer a conservative test of road improvement's influence on trade flows. Lastly, it is reasonable to assume that the economic incentives for smuggling of some goods between GMS economies have fallen over time as they have lowered tariff rates on many imports from their neighbors, which would be expected to reduce smuggling over time (other things being equal).

¹¹ Data sources (and data years available) were: Committee for Development of Cambodia (CDC) for Cambodia (1995-2002), Department of Roads, Ministry of Communication, Transport, Post and Construction (MCTPC) for Lao PDR (1992-2003); Department of Highways, Ministry of Transport for Thailand (1994-2003); and transport section of statistical yearbooks for Myanmar (1984-1996), Vietnam (1993-2002) and Yunnan Province (1990-2002), respectively.

¹² For Cambodia, road data by province were available only for 1995. This data was extrapolated to recent years based on the available data on total road length. For Thailand, road inventory data are not recorded by province but by the route of national highways that run through multiple provinces. Therefore, adjustment was made by the estimated provincial shares of road length of each highway based on the GIS-based "Road Inventory of ASEAN Highways" developed by UNESCAP. For Vietnam, road inventory data was available for only 1994. This data was extrapolated based on the available administrative data on freight tonnage and distance carried. Justification for this treatment is that freight carriages reflect to some extent "revealed" quality of roads that are used.

¹³ See Greene [2003] or other graduate econometric texts treating panel estimation procedures for further discussion of the estimators and specification tests reviewed briefly here.

¹⁴ For example, our estimation results are generally comparable to those reported in Frankel and Romer [1999], Soloaga and Winters [2001], Clarete *et al.* [2003], Rose [2004] and Yamarik and Ghosh [2005].

¹⁵ Given high covariance between available measures of domestic and cross-border road infrastructure, coefficient estimates that include both these variables must be interpreted with caution (i.e., multicollinearity problem), which is why we present models that include the cross-border and domestic road variables separately. Unfortunately, no usable instruments for either of our road measures could be identified and other approaches to solving potential problems of multicollinearity between these two variables of interest were considered impractical.

¹⁶ In addition to the explanatory variables discussed here, models estimates examined a number variables (e.g., dummy variables characterizing the export, import, and foreign investment environment), but these were not found to have statistically significant effects on trade and FDI under various specification, and are not reported in light of space constraints. Full results are available upon request from the authors.

¹⁷ In the estimates using shipping costs, estimated R^2 coefficients were in the range 48 and 70 percent and all F-tests/Wald Chi-square tests were statistically significant at the 0.01 level.

Table 1

DESCRIPTIVE STATISTICS FROM THE DATASET USED IN ESTIMATES

Variable	Units	Number observations			Mean	Std. Dev.	Minimum	Maximum	Sources and notes
Economy-pair identification code	n.a.	overall	N	690	353.5	170.6	102	605	1
		between	n	30					
		within	T	23					
Year	n.a.	overall	N	690	1992	6.6	1981	2003	
		between	n	30					
		within	T	23					
Trade and trade environment									
Economy i's exports to economy j	mil. current US\$	overall	N	475	112.75	288.84	0.00	2853.60	2,3,4
		between	n	29					
		within	T-bar	16,4					
Major exports from economy i to j	mil. current US\$	overall	N	171	74.71	125.43	0.04	845.01	5,6
		between	n	11					
		within	T	15,5					
Weighted average tariff rate	expressed in fraction	overall	N	525	0.158	0.174	0.023	1.050	7,8
		between	n	30					
		within	T-bar	17,5					
FDI flows									
Economy i's FDI inflow from economy j	mil. current US\$	overall	N	231	7.0569	13.677	-9.020	97.39	9
		between	n	21					
		within	T-bar	11					
Distance and roads									
Distance between economy i and j	kilometer	overall	N	690	802.4	344.4	217.0	1519.0	10,11
		between	n	30					
		within	T	23					
Freight cost between economy i and j	US\$ per box	overall	N	644	185	51.95	115	290	12
		between	n	28					
		within	T	23					
Economy i's road infrastructure in regions bordering economy j	km/km²	overall	N	219	0.079	0.072	0.008	0.283	13
		between	n	19					
		within	T-bar	11,5					
Economy i's road infrastructure in interior regions	km/km²	overall	N	345	0.078	0.073	0.009	0.299	13
		between	n	30					
		within	T-bar	11,5					

Table 1 (continued)

DESCRIPTIVE STATISTICS FROM THE DATASET USED IN ESTIMATES									
Variable	Units	Number observations			Mean	Std. Dev.	Minimum	Maximum	Sources and notes
Economic characteristics									
GDP	bil. current US\$	overall	N	570	26.05	42.11	0.60	181.50	7
		between	n	30					
		within	T-bar	19					
PPP ratio	relative real	overall	N	292	1.140	0.619	0.235	4.254	14
	price level	between	n	20					
	between economies	within	T-bar	14.6					
Other economy characteristics									
Total population	number (mil.)	overall	N	570	229.00	429.00	3.62	1290.00	7
		between	n	30					
		within	T	19					
Land area	square km (thou.)	overall	N	570	1,871	3,341	177	9,327	14
		between	n	30					
		within	T	19					

Notes and sources:

- Numbers 1 through 6 are assigned to Cambodia, Laos, Myanmar, Thailand, Vietnam and Yunnan Province in that order. Code number 102 indicates "Cambodia-to-Laos", 103 "Cambodia-to-Myanmar" and so on, and finally 605 "Yunnan-to-Vietnam".
- IMF Direction of Trade Statistics [2005].
- Yunnan statistical yearbooks (various years).
- Approximate adjustments were made to exclude river- and sea-born trade and gas trade. Yunnan exports are specific to Yunnan Province.
- UNCOMTRADE data from Statistics Canada's Trade Analyzer database [2005].
- Up to 5 commodities (HS 4 digits) were selected relying on available information on border trades in the subregion.
- ADB Key Indicators and statistical yearbooks of GMS members (various years).
- WATR is calculated by dividing customs revenue by imports. Weighting of trade items by value is done automatically by this procedure.
- Data for Cambodia, Laos, Myanmar, and Vietnam are approved amounts by investment approving authorities, adjusted by estimated average implementation ratios and smoothed by 5-year moving average. Data for Thailand are "net FDI inflows" recorded by the Bank of Thailand. Data for Yunnan Province are the "actually utilized" amount recorded in the provincial statistical yearbooks. Investments in energy are excluded.
- Distance based on approximate direct distance between cities, Oldfield [2004].
- Distance between capital cities was chosen, except for cases of Cambodia-Vietnam and Thailand-Vietnam where Ho Chi Minh City is used in preference to Hanoi since it represents largest Vietnamese city near the other two countries' capitals. See also Table 2.
- Interviews by Mr. Magnus Andersson. See Table 2 for more detail.
- Separate sources were used for the countries. See the text and Table 2 for details.
- World Bank, *World Development Indicators* [2005].

Table 2

DISTANCE AND SHIPPING COST BETWEEN MAJOR MARKETS IN GMS

		Country	Cambodia	Lao PDR	Myanmar	Thailand	Vietnam	Vietnam	Yunnan
		City	Phnom Penh	Vientiane	Yangon	Bangkok	Hanoi	HCMC	Kunming
Country	City		Distances (kilometers)						
Cambodia	Phnom Penh	Freight cost ¹	--	753	1101	530	1057	217	1519
Lao PDR	Vientiane		150	--	695	521	482	913	789
Myanmar	Yangon		265	-	--	575	1123	1316	1142
Thailand	Bangkok		150	115	179	--	981	754	1280
Vietnam	Hanoi		-	145	215	-	--	1141	555
	Ho Chi Minh City		150	-	-	141	-	--	1636
Yunnan	Kunming		250	218	290	141	181	-	--

Notes: Distances and freight costs are considered symmetric between indicated cities (i.e., same cost to ship, for example, from Bangkok to Kunming as Kunming to Bangkok).

¹ Shipping costs are defined as the cost in US\$ for transporting by air a 25 kg box with the dimensions (56 cm x 44 cm x 35 cm) between the cities indicated.

Source: Oldfield [2004] for distances, and interviews with shipping firms by Magnus Andersson [2007].

Table 3

MAJOR INTERNATIONAL CROSSING POINTS IN THE GREATER MEKONG SUBREGION

Bordering Countries	Border city/ Town	Province/State	Border city/Town	Province/State
Cambodia-Lao PDR	Trapeangkreal	Stung Treng Province	Khinak	Champassack Province
Cambodia-Thailand	Poipet	Bantreay Meanchey Province	Arayaprathet	Sa Kao Province
	Cham Yeam	Koh Kong Province	Hat Lek	Trat Province
Cambodia-Vietnam	Bavet	Xvay Rieng Province	Moc bai	Tay Ninh Province
Lao PDR-Thailand	Huayxay	Bokeo Province	Chiang Khong	Chiang Rai Province
	Thanaleng	Vientiane Municipality	Nong Khai	Nong Khai Province
	Thakhek	Khammouan Province	Nakhon Phanom	Nakohn Panom Province
	Savannakhet	Savannakhet Province	Mukdahan	Mukdahan Province
Lao PDR-Vietnam	Nam Phao	Borikhamxay Province	Cau Treo	Ha Tinh Province
	Densavanh	Savannakhet Province	Lao Bao	Quang Tri Province
Lao PDR-Yunnan	Boten	Luangnamtha Province	Mengla	Xishuanbanna Region
Myanmar-Thailand	Myawadi	Kayin State	Mae Sot	Tak Province
	Tachilek	Shan State	Mae Sai	Chiang Rai Province
Myanmar-Yunnan	Mongla	Shan State	Daluo	Xishuanbanna Region
	Muse	Shan State	Ruili	Baoshan Region
Vietnam-Yunnan	Lao Cai	Lao Cai Province	Hekou	Wenshan Region

Sources: UNESCAP Asian Highway database [2004], and regional maps and atlases.

Table 4

ESTIMATES OF TOTAL EXPORTS BETWEEN GMS COUNTRIES							
ESTIMATED COEFFICIENT							
STANDARD ERROR OF ESTIMATE	Total Exports	Total Exports	Total Exports	Total Exports	Total Exports	Total Exports	Total Exports
Coefficients	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7
	(Robust OLS)	(Robust OLS)	(Rand. Eff.)	(Robust OLS)	(Robust OLS)	(Robust OLS)	(Robust OLS)
Intercept	6.778	13.488	16.663	7.311	-9.707	8.533	3.558
	5.665	8.229	12.363	10.200	7.679	13.260	6.368
Distance between countries	-5.205***	-1.052	-5.912***	-2.471*		-2.465	-1.745**
	0.644	1.108	1.382	1.333		1.504	0.667
GDP exporter } GDP exp.* GDP imp.	1.620***	0.839***	1.097***	2.145***	1.081***	1.204***	0.328*
	0.179	0.247	0.302	0.626	0.259	0.255	0.184
GDP importer } --	1.332***			0.248			
	0.230			0.498			
Population exporter } Pop.exp.* Pop.imp.	-1.327**	-0.684	-1.910**	-2.200*	-0.081	-0.896	-0.726
	0.546	0.635	0.797	1.189	0.284	0.563	0.517
Population importer } --	-2.001***			0.505			
	0.555			1.364			
Area exporter } Area imp.* Area exp.	2.465***	0.976	3.381***	2.759**	0.574*	1.543**	1.367***
	0.688	0.818	0.983	1.263	0.301	0.681	0.611
Area importer } --	3.663***			0.260			
	0.701			1.269			
Cross-boarder roads exporter		1.705***		0.150	0.698	0.131	
		0.344		0.844	0.539	0.630	
Cross-boarder roads importer		1.196***		2.560***	3.151***	2.538***	
		0.383		0.902	0.821	0.789	
Domestic Roads exporter			0.552	0.542	0.029	0.634	
			0.419	0.956	0.482	0.615	
Domestic Roads importer			0.440	-1.921	-2.483***	-1.879***	
			0.418	1.361	0.795	0.708	

Table 4 (continued)

ESTIMATES OF TOTAL EXPORTS BETWEEN GMS COUNTRIES							
ESTIMATED COEFFICIENT							
STANDARD ERROR OF ESTIMATE	Total Exports	Total Exports	Total Exports	Total Exports	Total Exports	Total Exports	Total Exports
Coefficients	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7
	(Robust OLS)	(Robust OLS)	(Rand. Eff.)	(Robust OLS)	(Robust OLS)	(Robust OLS)	(Robust OLS)
Weighted average tariff rate importer						0.071	
						0.561	
Value of FDI from exporter to importer							0.068
							0.340
Value of FDI from importer to exporter							-0.029
							0.035
Sigma_u			2.643				
Sigma_e			1.723				
Rho			0.702				
Number Observations	392	156	222	131	131	128	146
Groups	29	18	26	14	14	14	16
Average years per group	13.5	8.7	8.5	9.4	9.4	9.1	9.1
R ²	0.509	0.541	0.444	0.632	0.596	0.617	0.282
F-Test or Wald Chi-square	20.39***	14.32***	51.10***	2954.57***	38.84***	26.80***	4.36***
degrees of freedom	[7,28]	[6,17]	[6]	[12,13]	[8,13]	[10,13]	[6,15]
Hausman test	22.74***	28.34***	0.95	3.98 ^{/1}	2.70*** ^{/1}	9.51 ^{/1}	4.70 ^{/1}
degrees of freedom	[4]	[4]	[4]	[9]	[7]	[8]	[4]
Breusch-Pagan Lagrange Multiplier test	77.62***	24.98***	184.25***	4.23**	5.15**	3.95**	204.63***

Notes: Statistical singificance of the parameter estimates: ***99%, **95%, and *90% confidence level, respectively. Continuous variables in the models are estimated in natural logarithms.

^{/1} Matrix of differences between fixed and random effects variance estimates is not positive definite.

Table 5

ESTIMATES OF MAJOR EXPORTS BETWEEN GMS COUNTRIES

ESTIMATED COEFFICIENT									
STANDARD ERROR OF ESTIMATE		Major	Major	Major	Major	Major	Major	Major	Major
		Exports	Exports	Exports	Exports	Exports	Exports	Exports	Exports
Coefficients		Model 8	Model 9	Model 10	Model 11	Model 12	Model 13	Model 14	Model 15
		(Robust OLS)	(Rand. Eff.)	(Rand. Eff.)	(Robust OLS)	(Robust OLS)	(Robust OLS)	(Robust OLS)	(Robust OLS)
Intercept		-7.724	2.378	1.273	11.006	1.483	22.255**	10.848	-3.718
		5.648	8.940	10.521	9.276	7.869	8.271	11.649	3.065
Distance between countries		3.410***	0.571	0.723	3.573**	5.210***	4.529***		-2.156
		1.078	1.241	1.504	1.403	1.304	1.006		2.994
GDP exporter	} GDP exp.* GDP imp.	0.231	0.323*	0.519***	0.170	0.236	-0.310	0.217	0.685***
		0.219	0.195	0.136	0.206	0.212	0.285	0.301	0.142
GDP importer	} --	0.639	0.715***						
		0.638	0.191						
Population exporter	} Pop.exp.* Pop.imp.	1.055			0.818	1.186**	1.240*	0.869*	-0.937
		0.609			0.572	0.371	0.601	0.434	0.587
Population importer	} --	-0.143							
		1.669							
Area exporter	} Area imp.* Area exp.	-1.889*			-1.948*	-2.591***	-3.121**	-1.141	1.906
		0.964			0.894	0.608	1.057	0.690	1.346
Area importer	} --	-0.316							
		2.193							
Cross-border roads exporter			1.087**	0.803***	1.357**	1.066**		3.402***	
			0.314	0.285	0.523	0.385		0.635	
Cross-border roads importer			0.635**	0.903***	1.210*	0.800**		1.253	
			0.303	0.281	0.551	0.339		0.905	
Domestic roads exporter							1.006***	-1.744**	
								0.247	0.634
Domestic roads importer							1.015***	-0.170	
								0.203	0.957

Table 5 (continued)

ESTIMATES OF MAJOR EXPORTS BETWEEN GMS COUNTRIES								
ESTIMATED COEFFICIENT								
STANDARD ERROR OF ESTIMATE	Major Exports	Major Exports	Major Exports	Major Exports	Major Exports	Major Exports	Major Exports	Major Exports
Coefficients	Model 8	Model 9	Model 10	Model 11	Model 12	Model 13	Model 14	Model 15
	(Robust OLS)	(Rand. Eff.)	(Rand. Eff.)	(Robust OLS)	(Robust OLS)	(Robust OLS)	(Robust OLS)	(Robust OLS)
Value of FDI from exporter to importer								-0.017
								0.017
Value of FDI from importer to exporter								0.098***
								0.010
Weighted average tariff rate importer					-0.337			
					0.366			
Sigma_u		0.977	1.266					
Sigma_e		0.485	0.488					
Rho		0.802	0.871					
Number of observations	169	78	78	78	78	102	78	70
Groups	11	9	9	9	9	11	9	8
Average years per group	15.4	8.7	8.7	8.7	8.7	9.3	8.7	8.8
R ² / ¹	0.470	0.589	0.487	0.717	0.741	0.667	0.725	0.684
F-Test or Wald Chi-square	11.79***	92.32***	90.32***	339.41***	420.5***	41.60***	296.46***	170.9***
degrees of freedom	[7,10]	[5]	[4]	[6,8]	[7,8]	[6,10]	[7,8]	[6,7]
Hausman test	42.71*** ^{/1}	5.78	0.93	4.88 ^{/1}	12.84*** ^{/1}	-- ^{/2}	5.89 ^{/1}	24.46*** ^{/1}
degrees of freedom	[4]	[5]	[4]	[4]	[5]	[4]	[6]	[4]
Breusch-Pagan Lagrange Multiplier test	260.79***	109.88***	129.50***	37.23***	30.96***	150.57***	14.25***	5.96***

Notes: Statistical singificance of the parameter estimates: *** 99%, ** 95%, and * 90% confidence level, respectively. Continuous variables in the models are estimated in natural logarithms.

^{/1} Matrix of differences between fixed and random effects variance estimates is not positive definite.

^{/2} Model estimates fail to meet asymptotic assumptions of the Hausman test.

Table 6

ESTIMATES OF FDI BETWEEN GMS COUNTRIES

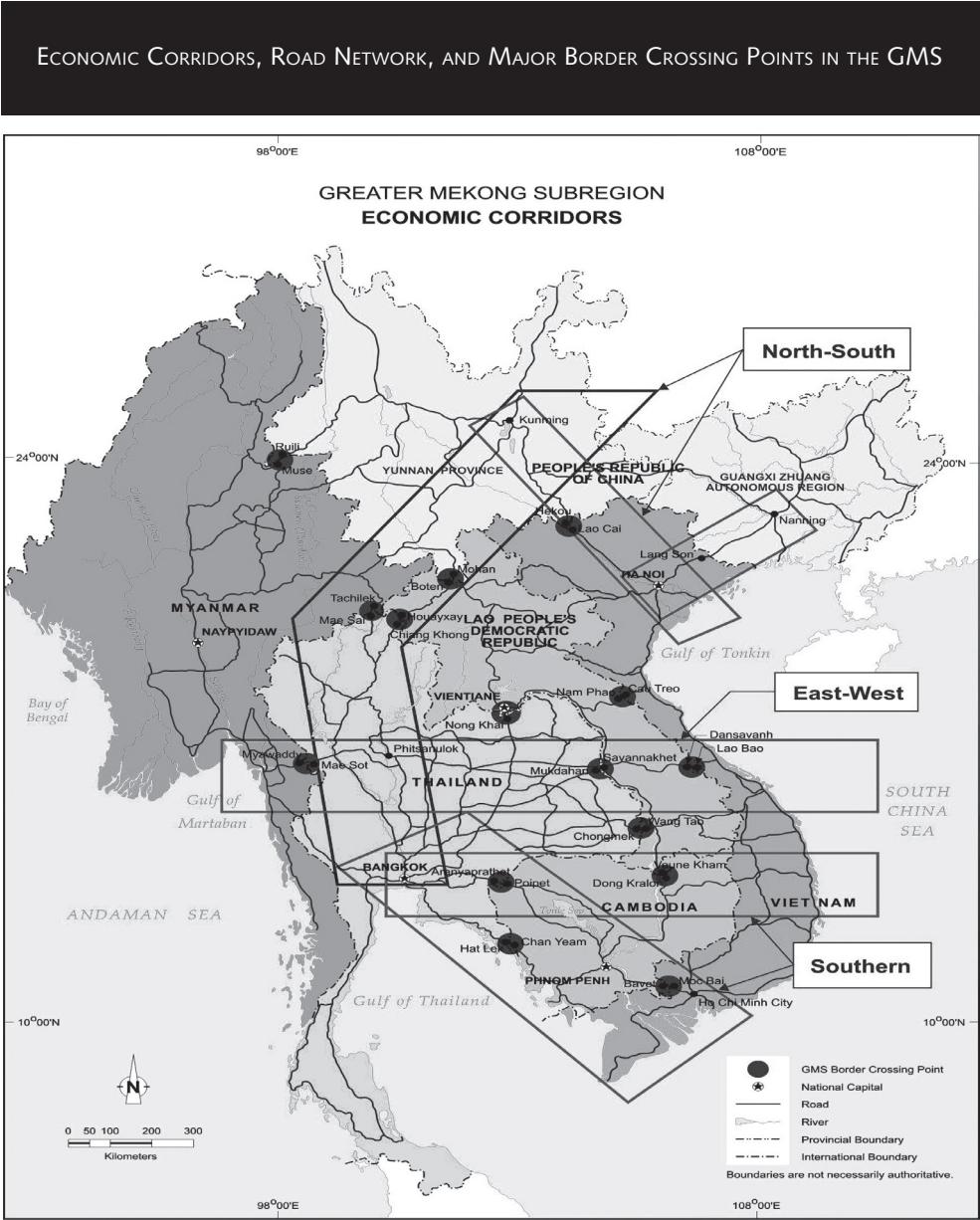
ESTIMATED COEFFICIENT		FDI		
STANDARD ERROR OF ESTIMATE		Model 16	Model 17	Model 18
Coefficients		(Robust OLS)	(Robust OLS)	(Robust OLS)
Intercept		-18.095 ***	-8.270	-30.650
		6.520	45.549	30.240
Distance between countries		0.626	0.181	2.081
		0.893	2.309	1.883
GDP exporter	} GDP exp.* GDP imp.	1.767 ***	2.663 ***	0.782 **
		0.274	0.913	0.292
GDP importer	} --	-0.555	-0.579	
		0.466	0.732	
Population exporter	} Pop.exp.* Pop.imp.	-1.180	-2.020	-0.238
		0.830	1.847	0.805
Population importer	} --	0.895	0.027	
		0.553	1.411	
Area exporter	} Area imp.* Area exp.	1.922	3.859	0.780
		1.137	2.322	0.744
Area importer	} --	-0.812	-0.951	
		0.680	3.780	
Cross-border roads exporter			1.760	1.702
			2.070	1.332
Cross-border roads importer			2.568	-0.351
			3.006	1.140
Domestic roads exporter			-2.708	-1.052
			3.146	2.181
Domestic roads importer			-0.992	-0.608
			2.331	1.043
PPP ratio				0.495
				0.969
Level of exports			-0.419	
			0.412	
Number Observations		219	112	95
Groups		21	14	11
Average years per group		10.4	8.0	8.6
R ²		0.394	0.406	0.370
F-Test		14.23 ***	73.81 ***	209.65 ***
degrees of freedom		[7,20]	[12,13]	[9,10]

Hausman test		23.75 ***	35.33 ^{/1}	21.79 ***/ ¹
degrees of freedom		[4]	[9]	[7]
Breusch-Pagan Lagrange Multiplier test		16.11 ***	5.32 **	1.13

Notes: Statistical singificance of the parameter estimates: *** 99%, ** 95%, and * 90% confidence level, respectively. Continuous variables in the models are estimated in natural logarithms.

^{/1} Matrix of differences between fixed and random effects variance estimates is not positive definite.

Figure 1



Source: ADB [2006], p.5.

Table 1A

ESTIMATES OF TOTAL EXPORTS BETWEEN GMS COUNTRIES								
ESTIMATED COEFFICIENT								
STANDARD ERROR OF ESTIMATE		Total	Total	Total	Total	Total	Total	Total
		Exports	Exports	Exports	Exports	Exports	Exports	Exports
Coefficients		Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7
		(Robust OLS)	(Robust OLS)	(Rand. Eff.)	(Robust OLS)	(Robust OLS)	(Robust OLS)	(Robust OLS)
Intercept		6.330	12.842	10.616	-12.613 [*]	-14.243 [*]	-8.408	0.187
		9.816	7.837	18.448	6.699	7.547	9.741	6.013
Shipping cost between countries		-4.503	-1.045	-3.667	-2.826		-3.419	1.393
		2.863	2.327	3.926	2.081		2.614	1.974
GDP exporter	} GDP exp.* GDP imp.	1.051 ^{**}	0.734 ^{***}	0.871 ^{**}	1.090 ^{***}	1.030 ^{***}	0.769 ^{**}	0.262
		0.392	0.186	0.361	0.243	0.244	0.312	0.196
GDP importer	} --	0.758			0.576			
		0.489			0.516			
Population exporter	} Pop. exp.* Pop. imp.	-0.435	-0.357	-1.003	-0.007	-0.027	0.165	-0.758
		0.787	0.489	1.030	0.602	0.411	0.371	0.517
Population importer	} --	-0.977			0.452			
		0.996			0.953			
Area exporter	} Area imp.* Area exp.	1.013	0.558	1.670	0.888	0.685	0.951 ^{**}	0.860 [*]
		0.940	0.484	1.189	0.630	0.441	0.423	0.465
Area importer	} --	1.988			0.803			
		1.130			0.806			
Cross-boarder roads exporter			1.806 ^{***}		2.056 ^{***}	1.940 ^{***}	2.110 ^{***}	
			0.361		0.469	0.493	0.508	
Cross-boarder roads importer			1.295 ^{***}		2.612 ^{***}	2.383 ^{**}	2.646 ^{***}	
			0.390		0.884	0.885	0.761	
Domestic Roads exporter				0.524	-1.239	-0.973 [*]	-1.135 ^{**}	
				0.474	0.802	0.559	0.530	

Table 1A

ESTIMATES OF TOTAL EXPORTS BETWEEN GMS COUNTRIES

ESTIMATED COEFFICIENT							
STANDARD ERROR OF ESTIMATE	Total	Total	Total	Total	Total	Total	Total
	Exports	Exports	Exports	Exports	Exports	Exports	Exports
Coefficients	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7
	(Robust OLS)	(Robust OLS)	(Rand. Eff.)	(Robust OLS)	(Robust OLS)	(Robust OLS)	(Robust OLS)
Domestic Roads importer			0.437	-2.243*	-1.951**	-2.169***	
			0.472	1.070	0.875	0.744	
Weighted average tariff rate importer						0.315	
						0.313	
Value of FDI from exporter to importer							0.065
							0.040
Value of FDI from importer to exporter							-0.032
							0.035
Sigma_u			3.680				
Sigma_e			1.723				
Rho			0.820				
Number Observations	386	156	222	156	156	153	146
Groups	28	18	26	18	18	18	16
Average years per group	13.8	8.7	8.5	8.7	8.7	8.5	9.1
R ²	0.317	0.538	0.224	0.604	0.572	0.595	0.238
F-Test or Wald Chi-square	3.83***	17.95***	26.23***	34.86***	26.59***	24.93***	4.67***
degrees of freedom	[7,27]	[6,17]	[6]	[11,17]	[7,17]	[9,17]	[6,15]
Hausman test	31.77***	29.85***	0.99	18.95** ^{/1}	4.97*** ^{/1}	14.86 ^{/1}	6.27 ^{/1}
degrees of freedom	[4]	[4]	[4]	[8]	[6]	[7]	[4]
Breusch-Pagan Lagrange Multiplier test	284.26***	20.97***	199.81***	8.18***	25.84***	15.40**	200.29***

Note: Statistical singificance of the parameter estimates: *** 99%, ** 95%, and * 90% confidence level, respectively. Continuous variables in the models are estimated in natural logarithms.

^{/1} Matrix of differences between fixed and random effects variance estimates is not positive definite.

Table 2A

ESTIMATES OF MAJOR EXPORTS BETWEEN GMS COUNTRIES							
ESTIMATED COEFFICIENT							
STANDARD ERROR OF ESTIMATE	Major Exports Model 8	Major Exports Model 9	Major Exports Model 10	Major Exports Model 11	Major Exports Model 12	Major Exports Model 13	Major Exports Model 15
Coefficients	(Robust OLS)	(Robust OLS)	(Rand. Eff.)	(Robust OLS)	(Robust OLS)	(Robust OLS)	(Robust OLS)
Intercept	-12.839**	18.990**	7.210	31.399***	31.423***	8.550	-6.320
	5.671	6.485	7.477	4.451	4.487	12.164	2.168
Shipping cost between countries	2.586***	-1.337	-0.161	0.949	0.766	0.544	1.075
	0.784	0.819	1.300	2.505	2.761	2.022	0.904
GDP exporter } GDP exp. * GDP imp.	0.995***	0.077	0.488***	-0.143	-0.135	0.499	0.796***
	0.216	0.191	0.134	0.241	0.211	0.360	0.179
GDP importer } --	1.339*	0.614**					
	0.617	0.189					
Population exporter } Pop. exp. * Pop. imp.	-0.346			0.520	0.488	0.047*	-1.082
	0.500			0.581	0.535	0.577	0.541
Population importer } --	-1.184						
	1.852						
Area exporter } Area imp. * Area exp.	0.367			-1.446	-1.366	-0.346	1.445
	0.710			1.250	1.210	0.860	0.603
Area importer } --	1.411						
	2.407						
Cross-border roads exporter		2.256**	0.861***	1.982***	1.985**		
		0.462	0.276	0.436	0.432		
Cross-border roads importer		1.150**	0.914***	1.776***	1.793***		
		0.395	0.277	0.389	0.400		
Domestic roads exporter						0.464	
						0.302	
Domestic roads importer						0.422	
						0.351	
Value of FDI from exporter to importer							-0.020
							0.016

Table 2A (continued)

ESTIMATES OF MAJOR EXPORTS BETWEEN GMS COUNTRIES							
ESTIMATED COEFFICIENT							
STANDARD ERROR OF ESTIMATE	Major Exports Model 8	Major Exports Model 9	Major Exports Model 10	Major Exports Model 11	Major Exports Model 12	Major Exports Model 13	Major Exports Model 15
Coefficients	(Robust OLS)	(Robust OLS)	(Rand. Eff.)	(Robust OLS)	(Robust OLS)	(Robust OLS)	(Robust OLS)
Value of FDI from importer to exporter							0.095***
							0.010
Weighted average tariff rate importer					0.041		
					0.364		
Sigma_u			1.166				
Sigma_e			0.488				
Rho			0.851				
Number of observations	169	78	78	78	78	102	70
Groups	11	9	9	9	9	11	8
Average years per group	15.4	8.7	8.7	8.7	8.7	9.3	8.8
R ² / ¹	0.479	0.7	0.499	0.644	0.645	0.516	0.690
F-Test or Wald Chi-square	24.23***	21.24***	89.34***	95.73***	68.96***	8.35***	57.82***
degrees of freedom	[7,10]	[5,8]	[4]	[6,8]	[7,8]	[6,10]	[6,7]
Hausman test	27.25*** ^{/1}	-2.23 ^{/2}	1.65	6.70 ^{/1}	0.12 ^{/1}	0.267 ^{/1}	22.26*** ^{/1}
degrees of freedom	[4]	[4]	[3]	[4]	[5]	[4]	[4]
Breusch-Pagan Lagrange Multiplier test	387.05***	65.42***	92.58***	38.74***	38.98***	238.86***	6.28**

Notes: Statistical singificance of the parameter estimates: *** 99%, ** 95%, and * 90% confidence level, respectively. Continuous variables in the models are estimated in natural logarithms.

^{/1} Matrix of differences between fixed and random effects variance estimates is not positive definite.

^{/2} Model estimates fail to meet asymptotic assumptions of the Hausman test.

Bibliography

ASIAN DEVELOPMENT BANK (ADB). "The Mekong Region: An Economic Overview". Manila: ADB. Available at <http://www.adb.org/Documents/Reports/MREO/default.asp>. 2004.

_____. "North-South Economic Corridor Executive summary". Manila: ADB. Available at <http://www.adb.org/GMS/Projects/flagshipA.asp>. 2006.

BERGSTRAND, JEFFREY H. "Comment: Determinants of Bilateral Trade: Does Gravity Work in a Neoclassical World?", in *The Regionalization of the World Economy* (Ed. J. A. Frankel), pp. 23-28. University of Chicago Press, Chicago. 1998.

BAIER, SCOTT AND JEFFREY H. BERGSTRAND. "The Growth of World Trade: Tariffs, Transportation Costs, and Intermediate Goods". Mimeo. University of Notre Dame, Notre Dame, Indiana. 1998.

CLARETE, RAMON; CHRISTOPHER EDMONDS AND JESSICA S. WALLACK. "Asian Regionalism and its Effects on Trade in the 1980s and 1990s", in *Journal of Asian Economics*, Vol. 14, pp. 91-131. New Brunswick, New Jersey: American Committee on Asian Economic Studies. 2003.

DE, PRABIR. "Effect of Transaction Cost on International Integration in the Asian Economic Community", in *Asian Economic Cooperation and Integration: Progress, Prospects, Challenges* (Ed. ADB), pp. 365-388, Manila: ADB. 2005.

DEARDORFF, ALAN V. "Determinants of Bilateral Trade: Does Gravity Work in a Neoclassical World" In: *The Regionalization of the World Economy*, (Ed. J. A. Frankel), NBER Project Report series, pp. 7-32. University of Chicago Press: Chicago. 1998.

FRANKEL, JEFFREY A. AND DAVID ROMER. "Does Trade Cause Growth?", in *American Economic Review*, Volume 89 N° 3, pp. 379-399. Nashville, Tennessee: American Economic Association. 1999.

FUJIMURA, MANABU. *Cross-Border Transport Infrastructure, Regional Integration and Development*. ADBI Discussion Paper N° 16. Tokyo: ADB Institute. 2004.

_____. AND CHRISTOPHER EDMONDS. *Impact of Cross-Border Transport Infrastructure on Trade and Investment in GMS*. ADBI Discussion Paper N° 48. Tokyo: ADB Institute. 2006.

- FUKAO, KYOJI; HIKARI ISHIDO AND KEIKO ITO. "Vertical Intra-industry Trade and Foreign Direct Investment in East Asia", in *Journal of the Japanese and International Economies*, 17(4), pp. 468-506. La Jolla, California. 2003.
- GREENE, WILLIAM H. *Econometric Analysis*. Fifth Edition. New Jersey: Prentice Hall Publishers, Upper Saddle River. 2003.
- INTERNATIONAL MONETARY FUND (IMF). *Direction of Trade Statistics (DOTS)*: CD-ROM. Washington DC: IMF. 2005.
- LIMAO, NUNO AND ANTHONY J. VENABLES. "Infrastructure, Geographical Disadvantage, Transport Costs and Trade", in *World Bank Economic Review*, Vol.15 pp. 451-479. Washington DC: World Bank. 2001.
- OLDFIELD, DAVID D. "Border Trade Facilitation and Logistics Development in the GMS: Component I - Review of Logistics Development in GMS". Report submitted to UNESCAP. Asia Policy Research Co. Ltd., Bangkok: UNESCAP. 2004.
- PONCET, SANDRA. "Economic Integration of Yunnan with the Greater Mekong Subregion", in *Asian Economic Journal*, Vol. 20 N° 3: pp. 303-317. Hong Kong/Osaka: East Asian Economic Association. 2006.
- POYHONEN, PENTTY. "A Tentative Model for the Volume of Trade between Countries", in *Weltwirtschaftliches Archiv*, 90, pp. 93-99. Kiel: Kiel Institute for the World Economy. 1963.
- RADELET, STEVEN AND JEFFREY SACHS. "Shipping Costs, Manufactured Exports, and Economic Growth". Paper presented at American Economic Association meeting, Harvard University. Cambridge, Massachusetts. 1998.
- REDDING, STEPHEN AND ANTHONY J. VENABLES. "Economic Geography and International Inequality. *Journal of International Economics*, Vol. 62, pp. 53-82. New York, NY and Madison, WI. 2004.
- ROSE, ANDREW K. "Do We Really Know That The WTO Increases Trade?", in *American Economic Review*, Vol. 94, pp. 98-114. Nashville, Tennessee: American Economic Association. 2004.
- SOLOAGA, ISIDRO AND L. ALAN WINTERS. "Regionalism in the Nineties: What Effect on Trade?", in *North American Journal of Economics and Finance*, Vol. 12, pp. 1-29. Ontario, Canada: North American Economics and Finance Association. 2001.

STATA CORP. *Stata Cross-Sectional Time-Series Reference Manual (Release 8)*. Stata Press, College Station: Texas. 2003.

STATISTICS CANADA. *Trade Analyzer Database* (CD-ROM). Statistics Canada, Ottawa. 2005.

TINBERGEN, JAN. *Shaping the World Economy: Suggestions for an International Economic Policy*. The Twentieth Century Fund, New York. 1962.

UNITED NATIONS ECONOMIC AND SOCIAL COMMITTEE FOR ASIA-PACIFIC (UNESCAP). *Road Inventory of ASEAN Highways* (CD-ROM). Bangkok: UNESCAP. 2004.

URATA, SHUJIRO. "Emergence of an FDI-Trade Nexus and Economic Growth in East Asia. In: *Rethinking the East Asian Miracle* (Eds. J. E. Stiglitz and S. Yusuf), pp. 409-459. Washington, D.C.: World Bank. 2001.

VIET NAM, GOVERNMENT OF. *Statistical Yearbook*. General Statistical Office, Hanoi. Various years.

WORLD BANK. *World Development Indicators* (CD-ROM). Washington, DC: World Bank. 2005.

YAMARIK, STEVEN AND SUCHARITA GHOSH. "A Sensitivity Analysis of the Gravity Model", in *The International Trade Journal*, Vol. 19, pp. 83-126. Texas A&M International University: Center for the Study of Western Hemispheric Trade. 2005.