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EVALUATING IMPACTS OF CROSS-BORDER TRANSPORT INFRASTRUCTURE IN THE GREATER MEKONG SUBREGION: THREE APPROACHES

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Abstract

This paper presents three approaches to the evaluation of cross-border transport infrastructure in the Greater Mekong Subregion (GMS). First, it estimates benefit-cost ratios for selected segments of economic corridors. The results indicate differing degrees of economic viability among different corridors. Second, it presents a panel data analysis on how economic corridor developments have impacted living standards at subnational level. The results indicate that economic corridors in the GMS as a whole show a positive net economic impact. Third, it presents a gravity model analysis on how economic corridors have affected intra-GMS trade. The results indicate positive effects of the development of economic corridors on intra-GMS trade in intermediate goods, especially for electric machinery. This implies that cross-border transport infrastructure in the GMS has contributed to lower service link costs and facilitated vertical integration across borders in this industry.

Keywords: project evaluation, cross-border infrastructure, regional integration

JEL Classification: F14, F15, O18

Contents

1. INTRODUCTION

The Greater Mekong Subregion (GMS), composed of Cambodia, Lao PDR, Myanmar, Viet Nam, Thailand, Yunnan province, and the Guangxi Autonomous Region of the People's Republic of China, has recently seen remarkable progress in the development of cross-border transport infrastructure along its "economic corridors" (Figure 1). Its significance lies in the corridors' contribution to higher regional economic growth through the promotion of intra-regional trade and investments than would be possible through the independent efforts of national investment projects alone. The evaluation, both *ex ante* and *ex post*, of such cross-border infrastructure projects requires two main additional analytical viewpoints relative to that for national projects, namely: (1) additional economic net impacts beyond national infrastructure developments, and (2) laying out of their benefit-cost distributions (Fujimura and Adhikari 2012).

The first point of "additionality" can be seen as a concept parallel to the economic concept of externalities in that it represents additional economic benefits or costs accruing to cross-border infrastructure projects that would not occur through national projects alone. Positive additionality would include growth impact through the enhancement of intra-regional trade and facilitation of border transactions (especially customs and inspections at land borders in the GMS) that would not arise through individual national efforts alone. Negative additionality would include induced illicit trades in timber, drugs, humans, wild animals, and arms due to lower costs of cross-border transport, and therefore, an expansion of underground economies in the region, which would not arise if regional connectivity were not advanced (Fujimura 2014).[1]

The second point of benefit-cost distribution also needs to be as transparent as possible for the evaluation of national projects, but it is much more critical for cross-border projects (Fujimura 2012). Making such distributional aspects transparent would help in identifying the areas where third parties (e.g., ADB and the Japanese government) can help fill the necessary gaps. In the context of the GMS, in particular, analytical efforts on distributional aspects would help policy discussions among less and more endowed members of the GMS and external players, and guide all parties toward creating win-win outcomes.

This paper is based on these motives and presents three different approaches to quantifying "additionalities" of cross-border transport infrastructure developments in GMS economic corridors.

[1] These negative aspects are difficult to evaluate quantitatively due to the informal nature of these activities and therefore beyond the scope of this paper.

Figure 1: Economic Corridors in the GMS

Source: ADB (2012, 11).

2. BENEFIT-COST COMPARISON FOR GMS ECONOMIC CORRIDORS

The author collected publicly available data on the construction of cross-border transport infrastructure and economic data at subnational level, and used them to roughly compare benefits against costs for selected segments of the main economic corridors in the GMS. The idea is to compare the cumulative incremental income reflected in local GDP measures along economic corridors with the cumulative economic cost of transport infrastructure development.

First, Yunnan and Lao PDR segments of the North-South Economic Corridor are examined (Table 1). The Thai segment of the corridor is omitted due to the difficulty of finding data on transport infrastructure costs in this segment.

The Yunnan segment of the corridor experienced an accelerated income growth in the late 2000s, particularly in the capital city of Kunming. As much of Kunming's economic growth is attributable to various urban investments other than the corridor investment such as the new airport, office buildings and condominiums, and subway construction, Kunming's GDP growth is excluded from the benefit side. On that basis, both Yunnan and Lao PDR segments of the corridor development show positive net benefits, with the Yunnan segment having a greater benefit-cost ratio. It appears that the Lao PDR segment does not have any large city and therefore agglomeration effects are limited. However, as the road construction for the Lao PDR segment was financed by concessional loans from the Chinese and Thai governments and ADB, the benefit-cost ratio for Lao PDR would be somewhat greater than the indicated figure. This makes sense as economic corridors encompassing more than two countries should bring about net benefits to all participants – a win-win outcome.

However, several shortcomings with the analysis that make the exercise far from exact must be pointed out. First, the analysis ignores income growth after 2011, spillover effects beyond the areas that the corridor route goes through, and other external benefits such as education and health facilitated by easier transport. To the extent that these benefits are greater, the analysis underestimates the benefit-cost ratio. Second, the analysis ignores many factors contributing to income growth other than the corridor investments – therefore, it overestimates the benefit-cost ratio to the extent of such missing variables. Third, the cost of road construction is based on the estimates at project completion. As the actual cost of road maintenance usually tends to exceed the estimate at the time of construction, the analysis overestimates the benefit-cost ratio to the extent of this tendency.

As the Fourth Mekong Friendship Bridge between Lao PDR and Thailand, completed in December 2013, is expected to accelerate corridor traffic, a reassessment of the corridor impact would be warranted in the future, including trade and investment effects among the three countries against the cost of the bridge.

Table 1: Benefit-cost Comparison for the North-South Corridor
(US$ million)

Administrative Unit	2008～11 Cumulative GDP Increase	Cumulative Cost of Road Development	Benefit-cost Ratio
Yunnan segment			
Kunming city	21,216	4,027	2.97 (excludes Kunming)
Yuxi city	7,438		
Pu’er city	2,773		
Xishuangbana region	1,732		
Yunnan total			
Lao PDR segment			
Luangnamtha province	111	137	1.55
Bokeo province	102		

Notes:

1. A compound rate of 12% (a standard discount rate used in ADB’s project evaluation) is applied to both road construction/maintenance costs and incremental GDP to calculate the present value in 2011 prices.
2. Cost data for the Yunnan segment are derived from documents regarding ADB support for the construction of the Yuxi-Pu’er expressway.
3. Cost data for the Lao PDR segment are derived from documents regarding ADB support for the construction of the Boten-Houayxai road.

Next, Viet Nam and Lao PDR segments of the East-West Economic Corridor are examined (Table 2). The Thai segment of the corridor is dropped from the analysis due to the difficulty of finding reliable data on the road construction and maintenance in Thailand. Due to the incomplete data on road construction in both the Lao PDR and Viet Nam segments, separation of benefits and costs between the two countries is not attempted.

The cost side of the corridor impact is derived from available data concerning road development between Da Nang (Viet Nam) and Mukdahan (Thailand), the Second Mekong Friendship Bridge between Savannakhet (Lao PDR) and Mukdahan (Thailand), and Hai Van Tunnel (Viet Nam) and Da Nang Port improvement (Viet Nam). As it is difficult to attribute the growth impact of each infrastructure component to specific geographical areas, three different estimates for the benefit-cost ratio are examined – very conservative, moderately conservative, and moderately optimistic. As Da Nang and Hue in Viet Nam are large economies, for which many variables other than the corridor development contribute to their growth, their GDP increases are excluded from the benefit side.

The very conservative estimate, which includes all infrastructure components mentioned above, yields a benefit-cost ratio of 0.69, namely negative net benefits. The moderately conservative estimate, which excludes the cost of Da Nang Port improvement, yields a benefit-cost ratio of 1.46. The moderately optimistic estimate, which excludes Hai Van Tunnel development, also yields a much improved benefit-cost ratio of 2.44.

As this corridor does not connect large cities such as Bangkok and Ho Chi Minh City, it was expected at the outset that its main impact would be poverty reduction in the low-income areas along the route. The analysis here confirms this expectation to some extent.

Table 2: Benefit-cost Comparison for the East-West Corridor
(US$ million)

Administrative Unit	2008～11 Cumulative GDP increase	Comment
Viet Nam segment		
Da Nang city	808.2	Da Nang is a port city. The Hai Van Pass used to separate Hue and Da Nang economies.
Thua-Thien Hue	437.1	
Quang Tri	233.4	Borders with Lao PDR on NR9 route.
Lao PDR segment		
Savannakhet	274.1	Borders with Viet Nam on NR9 route.
Cumulative costs		
Road development for NR1 in Viet Nam and NR9 in Viet Nam and Lao PDR	135.1	Viet Nam section supported by JICA, Lao section supported by ADB and JICA.
Road maintenance for NR9 in Lao PDR	39.9	Supported by JICA (but excludes O&M costs).
Second Mekong Friendship Bridge	73.3	Supported by JICA.
Hai Van Tunnel construction	139.2	Supported by JICA.
Da Nang Port improvement	87.1	Supported by JICA (but excludes O&M costs).
Benefit-cost ratio (excludes Da Nang and Hue on the benefit side)		
All cost items included	0.69	Very conservative estimate
Excludes Da Nang Port improvement	1.46	Moderately conservative estimate
Also excludes Hai Van Tunnel construction	2.44	Moderately optimistic estimate

Notes:

1. Same as Table 1.
2. Road development is divided among Da Nang-Dong Ha (NR1), Dong Ha-Phin (NR9), and Phin-Savannakhet (NR9). Its economic costs are approximated using data in ADB and JICA loan documents.
3. Costs for the Second Mekong Friendship Bridge and Hai Van Tunnel are derived from JICA's post-evaluation documents.

Again, shortcomings with the analysis include: a possible underestimation of benefits for post-2011 income growth; spillover effects beyond the direct route, and other external benefits; and a possible overestimation of benefits that are not attributable to the corridor development.

Next, the Cambodia and Viet Nam segments of the Southern Economic Corridor are examined (Table 3). The Thai segment of the corridor is again dropped from the analysis due to data difficulty. Also again, due to the inadequate data on road construction in both the Cambodia and Viet Nam segments, separation of benefits and costs between the two countries is not attempted.

The cost side of the corridor impact is derived from available data concerning road development between the Aranyaprathet (Thailand)-Poipet (Cambodia) border and Ho Chi Minh City (Viet Nam) via Phnom Penh (Cambodia). As Phnom Penh, Ho Chi Minch City, and Ba Ria Vuntau province are large port-based economies, for which many variables other than the corridor development contribute to their growth, their GDP increases are excluded from the benefit side.

As a result, the benefit-cost ratio is calculated to be 4.1, revealing the strong economic viability of this corridor. However, again, shortcomings with the analysis include: a possible underestimation of benefits for post-2011 income growth, spillover effects beyond the direct route, and other external benefits; and a possible overestimation of benefits that are not attributable to the corridor development.

As the new Mekong Bridge in Cambodia (at Neak Luong), completed in April 2015, is expected to accelerate corridor traffic, a reassessment of the corridor impact would be warranted in the future.

Table 3: Benefit-cost Comparison for the Southern Corridor
(US$ million)

Administrative Unit	2008～11 Cumulative GDP Increase	Comment
Cambodia segment		
Banteay Meanchay	242.1	Borders with Thailand to its west.
Battambang	363.8	NR5 runs south of Ton Le Sap Lake.
Pursat	128.7	
Kampong Chhnang	160.9	
Phnom Penh	817.5	Possesses river port.
Kandal	207.5	The Neak Luong Bridge was opened in April 2015 but its cost is excluded from this analysis. Completed.
Prey Veng	264.4	
Svay Rieng	134.4	Borders with Viet Nam to its southeast.
Viet Nam segment		
Tay Ninh	423.2	Borders with Cambodia to its northwest.
Ho Chi Minh City (HCMC)	5,529.8	Cai Mep-Chi Vai ports are under expansion between the HCMC and Vuntau ports but excluded from this analysis.
Ba Ria Vuntau	519.2	
Road development cumulative costs		
Poipet-Sisophone	16.5	Excludes O&M costs.
Sisophone-Neak Luong	41.0	Rehabilitation of this road section ignores sunk costs and underestimates total costs.
Neak Luong-HCMC	475.5	Excludes time costs for Mekong river ferry transport.
Aggregate benefit-cost ratio	4.1	Moderately optimistic estimate.

Notes:

1. Same as Table 1.

2. Costs for the analyzed section are approximated by using data included in documents for three ADB-assisted projects: Phnom Penh-Ho Chi Minh Highway, Poipet-Siem Reap road development, and Cambodia's national road network development.

As the above analyses show, some attempts at benefit-cost comparison are possible to see the impact of economic corridors in the GMS. However, serious analytical constraints exist: no comprehensive data publicly available on the cost side; difficulty in attributing each component of the corridor to the income growth of geographical regions along the corridor route (analytical rigor would call for multi-country and multi-regional economic modeling, which is beyond the scope of this paper), and difficulty in assessing counterfactual scenarios against which to compare the actual outcome. These constraints also apply to the analysis of domestic infrastructure projects but they are much more pronounced for cross-border projects. Therefore, the above results should be interpreted as the first rough attempts and are subject to reassessments as more reliable data (especially those on domestic public investments in each country) become available.

3. PANEL DATA ANALYSIS AT SUBNATIONAL LEVEL

In contrast to the approach taken in the above section, this section shows an approach to quantifying the impact of GMS economic corridors using an econometric model that involves major variables considered to influence living standards along the corridor routes.

Extending from the neoclassical growth accounting framework, the dependent variable is taken to be the growth rate of per capita GDP for each administrative unit while explanatory variables include population growth, physical capital growth, human capital growth, and then various dummy variables representing transport-related variables and economic corridors.

A basic estimation model is given as follows:

$$(\text{pcgdpgrowth})_{it} = c + \alpha(\text{popgrowth})_{it} + \beta(\text{capitalgrowth})_{it} + \gamma(\text{edugrowth})_{it} + \varepsilon_{it} \quad (1)$$

where c is a constant, and $(\text{pcgdpgrowth})_{it}$, $(\text{popgrowth})_{it}$, $(\text{capitalgrowth})_{it}$, and $(\text{edugrowth})_{it}$ represent the growth rate of per capita real GDP, population, physical capital, and human capital, respectively, for administrative unit i in year t. ε_{it} is an error term.

Human capital should in principle include health-related variables. However, due to large disparities in the kinds of health-related data across the GMS members, only education-related variables are adopted in the database.

The model is expanded by including transport-related variables in the road sector, represented by data on ownership or haulage of passenger and commercial vehicles (buses and trucks).

$$(\text{pcgdpgrowth})_{it} = c + \alpha(\text{popgrowth})_{it} + \beta(\text{capitalgrowth})_{it} + \gamma(\text{edugrowth})_{it} + \delta_1(\text{passvgrowth})_{it} + \delta_2(\text{comvgrowth})_{it} + \varepsilon_{it} \quad (2)$$

where $(\text{passvgrowth})_{it}$ and $(\text{comvgrowth})_{it}$ represent the growth rates of passenger and commercial vehicle ownership or haulage (measured in kilometers carried per passenger or kilometers carried per ton of cargo) for administrative unit i in year t.

Then the model is expanded further by including dummies representing economic corridors, international ports (air, river, and sea), and the presence of land borders (international and local) as follows:

$$(\text{pcgdpgrowth})_{it} = c + \alpha(\text{popgrowth})_{it} + \beta(\text{capitalgrowth})_{it} + \gamma(\text{edugrowth})_{it} + \delta_1(\text{passvgrowth})_{it} + \delta_2(\text{comvgrowth})_{it} + \theta_1(\text{crrdr\_all})_{it} + \theta_2(\text{cross\_intl})_i + \theta_3(\text{cross\_local})_l + \theta_4(\text{port\_air})_i + \theta_5(\text{port\_river})_i + \theta_6(\text{port\_sea})_i + \varepsilon_{it} \quad (3)$$

where $(crrdr\_all)_{it}$ represents the presence of any economic corridors in administrative unit i in year t, and $(cross\_intl)_i$, $(cross\_local)_i$, $(port\_air)_i$, $(port\_river)_i$, and $(port\_sea)_i$ represent the presence of an international land border (where third-country nationals can cross), a local land border (where only neighboring-country nationals can cross), an international airport, and international riverport, and an international seaport, respectively, in administrative unit i.

Panel data sets at subnational level are created, comprising 24 administrative units for Cambodia, 17 for Lao PDR, 14 for Myanmar, 63 for Viet Nam, 76 for Thailand, 16 for Yunnan province, and 14 for the Guangxi Autonomous Region, totaling 224 units in total. The data set for 2001–2012 is compiled from data documented in yearbooks for each country and province/region with some supplementary information where economic data are lacking, particularly for Cambodia, Lao PDR, and Myanmar.

Data constraints faced and adjustments made in creating the data set are summarized in Table 4. The location of economic corridors and criteria used for the dummy variables for each economic corridor are summarized in Table 5. Assignments of various dummy variables to each administrative unit are presented in Table 6.

Table 4 : Data Constraints and Adjustments Made in Creating the Data Set

	GDP	Population	Physical Capital	Human Capital	Road Transport Indicators
Cambodia	Data by province are not available.	Only occasional census data are available. Data in missing years are interpreted.	Data by province not available.	Three-year moving average for the number of teachers in general education is used.	Data by province are not available.
Lao PDR	Data for 2006–2010 collected by Dr. Masahi Ishida at IDE-JETRO are used.	Data by province are incomplete. Only those for 2007–2011 are used.	Data by province are not available.	Appropriate data by province are not available.	Data by province are not available.
Myanmar	Data by state/division not available.	Data after 2010 are truncated and excluded from the data set.	Data by state/ division are not available.	Three-year moving average for the number of high school students is used.	Three-year moving average for the road transport haulage is used.
Viet Nam	As GDP data by province are missing in many years, provincial income is substituted.	Complete data are available.	Three-year moving average for the fixed asset in the enterprise sector is used.	Three-year moving average for the number of university students is used.	Three-year moving average for the road transport haulage is used.
Thailand	Data after 2009 are truncated and excluded from the data set.	Data in 2004 are disrupted and excluded from the data set.	Three-year moving average for investments by firms registered at the Industry Ministry is used.	Appropriate data by province are not available.	The number of registered passenger and commercial vehicles is used. Data before 2004 are truncated and excluded from the data set.
Yunnan province	Complete data by city are available	Data in 2004–2007 are truncated and interpreted from their previous and subsequent years.	Data for fixed capital formation are used. But data after 2008 are missing.	Three-year moving average for the number of scientists is used.	The number of registered passenger and commercial vehicles is used. Data for 2001–2003 and 2006 are truncated and excluded from the data set.
Guangxi Autonomous Region	Complete data by city are available.	Data for 2010 are truncated and excluded from the data set.	Data for fixed capital formation are used.	Three-year moving average for the number of high school graduates is used.	The number of registered commercial vehicles is used.

Source: Data compiled by the author from various statistical yearbooks and personal contact.

Table 5: Location of Economic Corridors and Criteria for Assigning Dummy Values

Corridor	Route Location and Criteria for Assigning Dummy Values
Central Corridor (C1)	Connects Kunming in Yunnan province and Satahip port in Thailand via Vientiane in Lao PDR. No noticeable change observed throughout 2001–2012. A value of 1 is assigned to all administrative units located along the corridor throughout the data period.
Central Corridor (C2)	Connects Kunming and Sihanoukeville in Cambodia via NR13 in Lao PDR and NR7 and NR4 in Cambodia. NR13 in Lao PDR became functional after 2001 and NR7 in Cambodia was paved by 2007. A value of 1 is assigned to administrative units located along the corridor after these respective years.
Eastern Corridor (E1)	Connects Kunming and Ha Noi in Viet Nam via the Hekou border. The highway was constructed in Yunnan province in 2008. A value of 1 is assigned to administrative units in Yunnan province along the corridor after 2008. (A new railway was completed between Kunming and Hekou in 2013, and a new road opened between Hekou and Ha Noi in 2016, but these events are outside the data set period.)
Eastern Corridor (E2)	Connecting Ha Noi and Nanning in Guangxi via the Youyiguan/Huu Nghi border. Nanning-Youguiguan highway opened in 2005. A value of 1 is assigned to administrative units in Yunnan province along the corridor after 2005.
Eastern Corridor (E3)	Connects Ha Noi and Fangchenggang in Guangxi via the Donxing/Mong Cai border. Bai Chai bridge at Halong Bay opened in 2006. A value of 1 is assigned to administrative units in Viet Nam along the corridor after 2006.
North-South Corridor (NS)	Connects Kunming and Bangkok via northwestern Lao PDR. Kunming-Pu'er highway opened in 2004, the road between Jinghong and the Mohan/Boten border was upgraded by 2008, and the NR3 in northwestern Lao PDR was upgraded by 2009. A value of 1 is assigned to administrative units located along the corridor after these respective years.
Northern Corridor (N)	Connects Mandalay in Myanmar and Fangchenggang in Guangxi via Shan State, Kunming, and Nanning. The Ruili-Muse border trade zone was established and the roads from Mandalay to Muse and from Ruili to Kunming are considered to have been functional by 2005. A value of 1 is assigned to administrative units located along the corridor after 2005.
East-West Corridor (EW)	Connects Da Nang in Viet Nam and Mawlamyaine in Myanmar via southern Lao PDR and central Thailand. Hai Van tunnel opened and Da Nang port improvement was completed by 2006, and the second Mekong Friendship Bridge at the Savannakhet-Mukdahan border opened in 2008. A value of 1 is assigned to administrative units located along the corridor after these respective years.
Southern Corridor (S)	Connects Bangkok and Ho Chi Minh City via Phnom Penh. The road between Phnom Penh and Ho Chi Minh City was paved and upgraded by 2005. A value of 1 is assigned to administrative units located along the corridor after 2005. (The "Tsubasa" bridge at Neak Loung in Cambodia opened in 2015 but this event is outside the data set period.)
Southern Coastal Corridor (SC)	Connects Bangkok and Ca Mau in Viet Nam via eastern seaboard of Thailand and coastal Cambodia and Viet Nam. The coastal road between the Koh Kong border and Sihanoukville was upgraded by 2008. A value of 1 is assigned to administrative units in Cambodia located along the corridor after 2008. (The coastal road between Sihanoukville and the Viet Nam border had been upgraded by 2016 but this development is outside the data set period.)

Source: Various publicly available documents and the author's field observations.

Table 6: Information Used for Dummy Assignments to Each Administrative Unit

	Int'l Port	Land Border	Econ Corridor
Cambodia (provinces)			
1. Phnom Penh	Air, river		C2, S
2. Kandal		Local	C2, S
3. Kamong Cham			C2
4. Svay Rieng		Int'l, local	S
5. Prey Vent		Local	S
6. Takeo		Local	
7. Banteay Meanchey		Int'l	S
8. Battambang			S
9. Kampong Chhnang			S
10. Kampong Thom			
11. Siem Reap	Air		
12. Oddar Meanchey		Local	
13. Pailin		Int'l	
14. Pursat			S
15. Kampot		Int'l	SC
16. Koh Kong		Int'l	SC
17. Kep			SC
18. Preah Sihanouk	Sea		C2, SC
19. Kampong Speu			C2
20. Kratie			C2
21. Mondulkiri		Local	
22. Preah Vihear		Local	
23. Ratanakiri		Int'l	
24. Steung Treng		Int'l	C2
Lao PDR (provinces)			
1. Vientiane City	Air	Int'l	NS, C1, C2
2. Phongsaly		Int'l, local	
3. Luang Namtha		Int'l, local	NS, C1, C2
4. Oudomxay			C1, C2
5. Bokeo	River	Int'l, local	NS
6. Luang Prabang	Air, river		C1, C2
7. Houaphan		Int'l	
8. Xayaburi	River	Local	
9. Xieng Khouang			
10. Vientiane (province)			C1, C2
11. Bolikhamxay	River	Int'l	C2
12. Khammouan	River	Int'l	C2
13. Savannakhet	Air, river	Int'l	C2, EW
14. Salavan			C2
15. Sekong			
16. Champasak		Int'l	C2
17. Attapeu		Int'l	

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Table 6 *continued*

	Int'l Port	Land Border	Econ Corridor
Myanmar			
1. Kachin State		Local	
2. Kayah State		Local	
3. Kayin State		Int'l	EW
4. Chin State			
5. Sagain Division		Int'l	N
6. Tanintharyi Division	Sea	Int'l	S
7. Bago Division			
8. Magwe Division			
9. Mandalay Division			N
10. Mon State			EW
11. Rhakine State		Local	
12. Yangon Division	Air, sea		
13. Shan State		Int'l, local	N, NS
14. Aeyarwady Division			
Viet Nam (provinces)			
1. Ha Noi City	Air		E1, E2, E3
2. Vinh Phuc			E1
3. Bac Ninh			E2
4. Quang Ninh		Int'l	E3
5. Hai Duong			E3
6. Hai Phong City	Air, sea		E3
7. Hung Yen			E3
8. Thai Binh			
9. Ha Nam			
10. Nam Dinh			
11. Ninh Binh			
12. Ha Giang		Local	
13. Cao Bang		Local	
14. Bac Kan			
15. Tuyen Quang			
16. Lao Cai		Int'l, local	E1
17. Yen Bai			E1
18. Thai Nguyen			
19. Lang Son		Int'l, local	E2
20. Bac Giang			E2
21. Phu Tho			E1
22. Dien Bien		Int'l	
23. Lao Chau		Local	
24. Son La		Local	

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Table 6 *continued*

	Int'l Port	Land Border	Econ Corridor
25. Hoa Binh			
26. Thanh Hoa		Local	
27. Nghe An		Local	
28. Ha Tinh		Int'l	
29. Quang Binh		Int'l, local	
30. Quang Tri		Int'l, local	EW
31. Thua Thien-Hue City			EW
32. Da Nang City	Air, sea		EW
33. Quang Nam			
34. Quang Ngai			
35. Binh Dinh			
36. Phu Yen			
37. Khanh Hoa			
38. Ninh Thuan			
39. Binh Thuan			
40. Kon Tum		ローカル	
41. Gia Lai		国際	
42. Dak Lak		ローカル	
43. Dak Nong		ローカル	
44. Lam Dong			
45. Binh Phuoc		ローカル	
46. Tay Ninh		国際・ローカル	S
47. Binh Duong			
48. Dong Nai			
49. Ba Ria-Vung Tau	Sea		S
50. Ho Chi Minh City	Air, river		S
51. Long An		Local	
52. Tien Giang			
53. Ben Tre			
54. Tra Binh			
55. Vinh Long			
56. Dong Thap		Local	
57. An Giang		Int'l, local	
58. Kien Giang		Int'l	SC
59. Can Tho			
60. Hau Giang			
61. Soc Trang			
62. Bac Lieu			
63. Ca Mau			SC

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Table 6 *continued*

	Int'l Port	Land Border	Econ Corridor
Thailand (provinces)			
1. Bangkok City	Air, river		NS, S, SC
2. Samut Prakan			SC
3. Nonthaburi			S
4. Pathumthani			NS
5. Nakhon Pathom			S
6. Samut Sakhon			
7. Phrana Si Ayuthaya			NS
8. Ang Thong			NS
9. Lopburi			
10. Singburi			NS
11. Chainat			
12. Saraburi			
13. Chonburi	Sea		C1,SC
14. Rayong			SC
15. Chanthaburi			SC
16. Trat		Int'l	SC
17. Chachoengsao			C1, S, SC
18. Prachinburi			C1, S
19. Nakhon Nayok			S
20. Sa Kaew		Int'l, local	S
21. Ratchaburi			
22. Kanchanaburi		Int'l	S
23. Suphanburi			
24. SAmut Songkhram			
25. Petchaburi			
26. Prachuap Khiri Khan		Local	
27. Chiang Mai	Air		
28. Lamphun			
29. Lampang			
30. Uttaradit			NS
31. Phrae			NS
32. Nan		Local	
33. Phayao			NS
34. Chiang Rai	Air, river	Int'l	NS
35. Mae Hong Son			
36. Nakhon Sawan			NS
37. Uthaithani			
38. Kamphaeng Phet			
39. Tak		Int'l	EW, NS
40. Sukhothai			EW

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Table 6 *continued*

	Int'l Port	Land Border	Econ Corridor
41. Phisanulok			EW, NS
42. Phichit			NS
43. Phetchabun			EW
44. Nakhon Ratchasima			C1
45. Buriram		Local	
46. Surin		Local	
47. Sisaket		Local	
48. Ubon Ratchathani		Int'l, local	C2
49. Yasothon			
50. Chaiyaphum			
51. Amnat Charoen			
52. Nong Bua Lamphu			
53. Khon Kaen			C1, EW
54. Udon Thani			C1
55. Loei		Local	
56. Nong Khai	River	Int'l, local	C1
57. Maha Sarakham			
58. Roi Et			
59. Kalasin			EW
60. Sakon Nakhon			
61. Nakhon Phanom	River	Int'l	C2
62. Mukdahan	River	Int'l	EW
63. Nakhon Si Thammarat			
64. Krabi			
65. Phang Nga			
66. Phuket	Air		
67. Surat Thani			
68. Ranong	Sea	Int'l	
69. Chumphon			
70. Songkhla	Air	Int'l, local	
71. Satun		Local	
72. Trang			
73. Patthalung			
74. Patthani			
75. Yala		Local	
25. Narathiwat		Int'l	
Yunnan Province			
1. Kunming City	Air		E1, NS, N
2. Qujing City			E1, NS
3. Yuxi City			N
4. Baoshan City			
5. Zhaotong City			

continued on next page

Table 6 *continued*

	Int'l Port	Land Border	Econ Corridor
6. Lijiang City			
7. Pu'er City	River		NS
8. Lincang City		Local	
9. Chuxiong Yi Automonous Prefecture			N
10. Honghe Hani and Yi Aut. Pref.		Int'l	E1, N
11. Wenshan Zhuang and Miao Aut. Pref.		Local	N
12. Xishuangbanna Dai Aut. Pref.	River	Int'l, local	NS
13. Dali Bai Autonomous Prefecture			N
14. Dehong Dai and Jimpo Aut. Pref.		Int'l	N
15. Nujian Lisu Autonomous Prefecture		Local	
16. Deqen Tibetan Autonomous Pref.			
Guangxi Autonomous Region			
1. Nanning City	Air		E2, N
2. Liuzhou City			
3. Guilin City			
4. Wuzhou City			
5. Beihai City	Sea		
6. Fangchenggang City	Sea	Int'l, local	E3, N
7. Qinzhou City			N
8. Quigang City			
9. Yulin City			
10. Baise City		Local	N
11. Hezhou City			
12. Hechi City			
13. Laibin City			
14. Chongzuo City		Int'l, local	E2

Notes: In the second column, "air," "sea," and "river" indicate the presence of an international airport, seaport, and riverport, respectively, in the administrative unit. In the third column, "int'l" and "local" indicate the presence of international and local border-crossing points, respectively, in the administrative unit. The third column indicates which economic corridor(s) crosses the administrative unit.

Source: Various publicly available documents and the author's field observations

The estimation results are summarized in Table 7. Estimation models are chosen from the result of the Hausman test as shown in the second row of Table 7.

The basic model (equation 1) yielded largely expected signs of the coefficients: negative for population growth, positive for physical capital growth, and positive and statistically significant for human capital growth. Given the very unbalanced data set due to missing data particularly for Cambodia, Lao PDR, and Myanmar, these results indicate that the basic model is workable as a starting point for explaining changes in the living standards of the GMS at subnational level.

Table 7: Estimation Results for Panel Data Analysis at Subnational Level
(Dependent variable = per capita GDP growth)

Explanatory Variables	Model 1 Cross-sectional Fixed Effects	Model 2 Cross-sectional Random Effects	Model 3 Cross-sectional Random Effects	Model 4 Period Random Effects
Constant	0.0773***	0.0419***	0.0383***	0.0778***
Population growth	–0.2768	–0.2731	–0.1051	
Physical capital growth	0.0057	0.0068	0.0052	
Human capital growth	0.0418*	0.0309*	0.0322*	
Road transport growth for passengers		0.1478***	0.1482***	
Road transport growth for cargo		0.0709**	0.0794**	
Dummy for international land border			–0.0084	
Dummy for local land border			0.0046	
Dummy for international airport			–0.0363**	
Dummy for international riverport			–0.0061	
Dummy for international seaport			0.0054	
Dummy for all economic corridors			0.0150*	
Dummy for C1 corridor				0.0055
Dummy for C2 corridor				–0.0108
Dummy for E1 corridor				–0.0263*
Dummy for E2 corridor				0.0124
Dummy for E3 corridor				0.0084
Dummy for EW corridor				–0.0026
Dummy for N corridor				0.0636***
Dummy for NS corridor				0.0359***
Dummy for S corridor				–0.0092
Dummy for SC corridor				–0.0254**
Sample size	490	369	369	1,743
R^2	0.2931	0.0927	0.1131	0.0519

Note: ***, **, and * indicate statistical significance at the 1%, 5%, and 10% level, respectively.

Model 2 (equation 2), which includes road transport-related variables, yielded positive and statistically significant coefficients for the two variables representing growth in passenger and cargo traffic. This implies that traffic growth at subnational level contributes to a greater growth in living standards in the GMS. Correlation analysis between the explanatory variables in Model 2 yielded maximum coefficients of less than 0.3 and indicates a small likelihood of multicollinearity problems.

Model 3 (equation 3), which includes various dummies for cross-border transport infrastructure, yielded similar results on road transport-related variables as well as two statistically significant coefficients. The first is a positive coefficient for the dummy for all economic corridors in the GMS combined. The choice of the dummy values (1 or 0) followed the author's long-term observations on the developments of individual corridors (Table 5). This indicates that the development of economic corridors in the GMS as a whole has had an additionally positive impact on the region's living standards. The second is a negative coefficient for the dummy for international airports. While various interpretations would be possible for this result, one could argue that the administrative units with international airports would have achieved high living standards by 2000 and those units have experienced a relatively slower growth with the other conditions being equal. If so, this result could be interpreted as some evidence of convergence occurring in the GMS – a long-term desirable sequence of economic corridors causing agglomeration first and then dispersion.

The effects of the development of individual economic corridors could not be estimated using various extensions from the basic model due to a large unbalanced data set. Therefore, with no theoretical rigor, a simple regression including dummies for all individual economic corridors was attempted as in Model 4. This would at least say something about the relative impact of these corridors among themselves. The results included four statistically significant coefficients. The Northern Corridor (connecting central Myanmar through Shan state and Yunnan province with the coastal city of Fangchenggang in the Guangxi Autonomous Region) and the North-South Corridor (connecting Kunming in Yunnan province through northwestern Lao PDR with Bangkok) had positive coefficients. These two corridors appear to have already had positive economic impacts during the data period. On the other hand, Eastern Corridor 1 (connecting Kunming and Ha Noi) and the Southern Coastal Corridor (connecting Bangkok via coastal Cambodia with the southernmost Vietnamese city of Ca Mau) had negative coefficients. The deplorable condition of the road between Lao Cai and Ha Noi up to 2012 for the former and relatively small traffic along the Cambodian and Vietnamese coastal routes for the latter, as witnessed by the author, may have been behind these results.

The above analysis, despite its much constrained data, was able to confirm a positive additionality of GMS economic corridors as a whole. In addition, it yielded an interesting result that may suggest that dispersion effects after agglomeration effects have begun to emerge. However, it was not possible to separate and identify the impacts of individual corridors due to serious data limitation. While the advantages of panel data analysis lie in an increased number of observations and improved reliability of causality among variables, the author must admit that the limited data set has restricted the scope of the analysis. In particular, estimation models including a dummy for economic corridors could not pick up fixed effects for administrative units or periods, and therefore could not provide detailed interpretations that are specific to geography and time. These would remain the issues for similar analyses in the future.

4. GRAVITY MODEL ANALYSIS OF INTRA-GMS TRADE

The third approach to quantifying the impact of cross-border transport infrastructure in the GMS is to use a gravity model to measure its additional impact on intra-regional trade.

An earlier analysis by Edmonds and Fujimura (2008) applied data for the period 1981–2003 to intra-GMS trade and found that improvement of cross-border road infrastructure (measured in road density) had an additional incremental effect on intra-regional trade via land borders in the GMS. In contrast, Taguchi (2013) applied panel data between Thailand and its trading partners for the period 1980–2010 and found that Thailand's trade intensity was lower with its partners in the Mekong region than with those outside the region, implying that service link costs within the region were still higher than outside the region.

Here we present a recent analysis by Ono and Fujimura (2015) that examined the effects of transport infrastructure development on intra-GMS trade. In particular, we focus on the intra-GMS trade in electric and transport machinery as trades in these manufacturing industries would reflect vertical integration across borders through a reduction in service-link costs. We divide the trades between final and intermediate goods to see whether the latter would have a larger increase than the former, which would provide clearer evidence of the reduction in service link costs.

Before getting into a gravity model analysis, we take a look at the broad trend in intra-GMS trade. Table 8 shows intra-GMS trade in 2000, 2006, and 2012. Broadly speaking, each GMS member's dependence on intra-regional trade increased over these years. While missing data for Myanmar, Yunnan, and Guangxi in 2012 prevented drawing a clear picture of the recent trend, regional trade between Myanmar and Yunnan province and the Guangxi region had presumably been expanding rapidly given their geographical proximity and the opening up of Myanmar's economy in recent years. If adequate trade data were available, intra-GMS trade would be shown to have been expanding faster than Table 7 indicates (the numbers with questions marks would be much larger in reality).

Table 8: Trends in Intra-GMS Trade
($US million)

		Importer				
2000		Cambodia	Lao PDR	Myanmar	Viet Nam	Thailand
Exporter	Cambodia	X	3	0	19	23
	Lao PDR	0	X	n.a.	96	69
	Myanmar	0	n.a.	X	3	233
	Viet Nam	142	71	6	X	372
	Thailand	347	381	504	838	X
	Yunnan	1	13	293	93	24
	Guangxi	n.a.	n.a.	n.a.	222	23
	GMS total	490	468	803	1,271	744

		Importer				
2000		Yunnan	Guangxi	GMS Total	Total Exports	GMS Share
Exporter	Cambodia	0	n.a.	45	1,123	4%
	Lao PDR	6	n.a.	171	330	52%
	Myanmar	70	n.a.	306	1,646	19%
	Viet Nam	8	69	668	14,483	5%
	Thailand	8	22	2,100	68,963	3%
	Yunnan	X	n.a.	424	1,175	36%
	Guangxi	n.a.	X	245	1,493	16%
	GMS total	92	91	3,959	89,213	4%

continued on next page

Table 8 *continued*

	2006	Importer: Cambodia	Lao PDR	Myanmar	Viet Nam	Thailand
Exporter	Cambodia	X	0	0	75	15
	Lao PDR	1	X	n.a.	107	455
	Myanmar	0	n.a.	X	51	2,135
	Viet Nam	245	83	15	X	822
	Thailand	1,235	1,025	761	3,098	X
	Yunnan	1	65	541	208	96
	Guangxi	n.a.	n.a.	n.a.	750	51
	GMS total	1,482	1,173	1,317	4,289	3,574

	2006	Importer: Yunnan	Guangxi	GMS Total	Total Exports	GMS Share
Exporter	Cambodia	0	n.a.	90	3,562	3%
	Lao PDR	13	n.a.	576	882	65%
	Myanmar	224	n.a.	2,410	4,5000	54%
	Viet Nam	53	717	1,935	39,605	5%
	Thailand	16	30	6,165	130,790	5%
	Yunnan	X	n.a.	911	1,342	68%
	Guangxi	n.a.	X	801	3,599	22%
	GMS total	306	747	12,888	184,280	7%

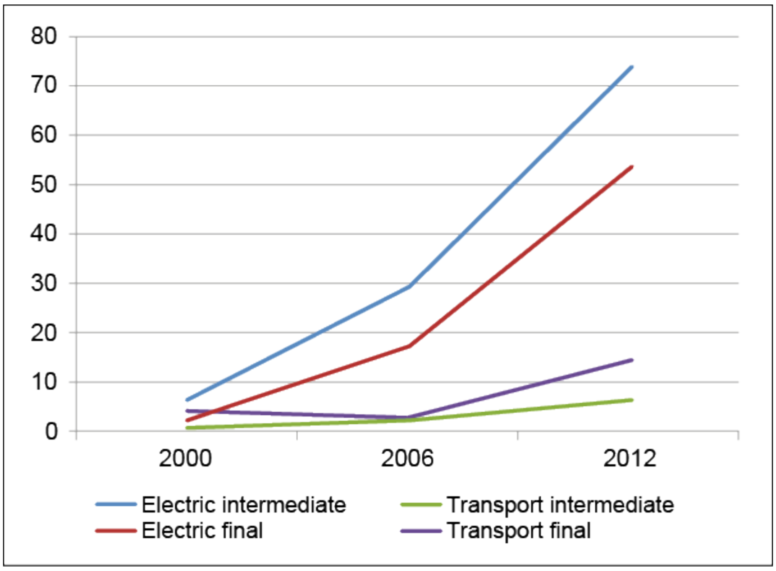
	2012	Importer: Cambodia	Lao PDR	Myanmar	Viet Nam	Thailand
Exporter	Cambodia	X	1	n.a.	442	228
	Lao PDR	2	X	n.a.	404	1,131
	Myanmar	0	n.a.	X	100	3,363
	Viet Nam	2,831	421	118	X	2,832
	Thailand	3,761	3,567	3,108	6,443	X
	Yunnan	7	152	n.a.	829	439
	Guangxi	n.a.	n.a.	n.a.	827	226
	GMS total	6,601	4,141	3,226	9,045	8,219

	2012	Importer: Yunnan	Guangxi	GMS Total	Total Exports	GMS Share
Exporter	Cambodia	n.a.	n.a.	671	8,200	8%
	Lao PDR	195	n.a.	1,732	2,400	72%
	Myanmar	n.a.	n.a.	3,463	8,877	39%?
	Viet Nam	217	146	6,565	115,458	6%
	Thailand	262	8	17,149	228,178	8%
	Yunnan	X	n.a.	1,427	10,018	14%?
	Guangxi	n.a.	X	1,053	9,722	11
	GMS total	674	154	32,060	382,853	8%?

Data source: IMF Direction of Trade for Cambodia, Lao PDR, Myanmar, Thailand, and Viet Nam, and statistical yearbooks for Yunna province and the Guangxi Autonomous Region.

Next, Figure 2 shows trends in the intra-GMS trade in electric and transport machinery divided between intermediate and final goods. We collected pairwise trade data from the UN Comtrade database and applied them to the categorization of intermediate and final goods devised by RIETI (Research Institute of Economy, Trade and Industry, Japan). Due to the data constraints we faced for Yunnan province and the Guangxi Autonomous Region individually (their statistical yearbooks do not include partner-wise trade by commodity grouping), we use the People's Republic of China's aggregate trade data together with those of the other five countries. Figure 2 indicates that intra-GMS trade in each of the four categories is on an increasing trend, with that in intermediate goods in electric machinery being the fastest growing. This seems to imply that in the electric machinery industry, vertical integration across national borders in the GMS is well advanced and final goods are exported to markets outside the GMS. In contrast, in the transport machinery industry, intermediate goods may be mostly imported from countries outside the GMS such as Japan and Germany, assembled in major producing countries such as Thailand, the PRC, and Viet Nam (predominantly motorbikes for Viet Nam), and the final goods may be marketed mainly within the GMS.

Figure 2: Intra-GMS Trade in Electric and Transport Machinery
(US$ billion)



Data source: RIETI Trade Industry Database 2012.

Now we use a gravity model to investigate the extent to which cross-border transport infrastructure contributed to these expansions in intra-GMS trade. The gravity model has been a popular analytical tool among trade economists since 1990s. Its logic is borrowed from Newton's law of universal gravitation, which states that any two masses attract each other with a force equal to a constant multiplied by the product of the two masses and divided by the square of the distance between them. A trade application of this law is modified such that a modified trade volume between two economies increases proportionately to the product of their GDPs and inversely proportionately to the distance between them:

$$T_{ij} = A\frac{Y_i Y_j}{D_{ij}} \quad (4)$$

where T_{ij} is the trade volume between economy i and economy j, A is a constant, Y_i and Y_j are GDP for economy i and economy j, respectively, and D_{ij} is the distance between them. Taking the logarithm of equation (4) in the form of an estimation model yields:

$$\log T_{ij} = \alpha + \beta_1 \log(Y_i) + \beta_2 \log(Y_j) + \beta_3 \log(D_{ij}) + \varepsilon_{ij} \qquad (5)$$

This is the simplest form of gravity model upon which many trade economists expanded. Anderson and van Wincoop (2003) suggest that additional explanatory variables include language, free trade agreement, price levels/real exchange rate, etc. In our analysis, we add variables representing cross-border infrastructure development in the GMS.

We modify the basic equation and add per capita GDP for trading partners in order to separate the effects of the diverse income levels of GMS members as below. Per capita GDP also acts as a proxy for the degree of capital intensity as an important determinant for trades in the machinery manufacturing sector.

$$\begin{aligned} \ln M_{\mathrm{ijt}} = {} & \alpha + \beta_1(\ln GDP_{it}) + \beta_2(ln GDP_{jt}) + \beta_3\,(\ln\ GDP\ percapita_{it}) \\ & + \beta_4\,(\ln GDP\ per\ capita_{jt}) + \beta_5(\ln\ \ Distance_{ij}) + \varepsilon_{ijt} \end{aligned} \qquad (6)$$

where M_{ijt} is an import value of country i from country j in year t, GDP_{it} and GDP_{jt} are GDP for country i and country j, respectively, in year t, *GDP per capita*$_{it}$ and *GDP per capita*$_{jt}$ are per capita GDP for country i and country j, respectively, in year t, and Distance$_{ij}$ is the distance between the two countries. ε_{ijt} is an error term.

We can further add a dummy variable (denoted as *INFRA*) that represents a combination of events that reflect improvement in cross-border transport infrastructure in the GMS as summarized in Table 5 in the previous section:

$$\begin{aligned} \ln M_{\mathrm{ijt}} = {} & \alpha + \beta_1(\ln \mathrm{GDP_{it}}) + \beta_2(\ln \mathrm{GDP_{jt}}) + \beta_3\,(\ln\ GDP\ percapita_{it}) \\ & + \beta_4\,(\ln GDP\ per\ capita_{jt}) + \beta_5(\ln\ \ \mathrm{Distance}_{ij}) + \beta_6 INFRA + \varepsilon_{ijt} \end{aligned} \qquad (7)$$

Furthermore, we can construct an estimation model that includes dummy variables representing individual events refecting cross-border transport infrastructure development as follows:

$$\begin{aligned} \ln M_{\mathrm{ijt}} = {} & \alpha + \beta_1(\ln \mathrm{GDP_{it}}) + \beta_2(\ln \mathrm{GDP_{jt}}) + \beta_3\,(\ln\ GDP\ percapita_{it}) \\ & + \beta_4\,(\ln GDP\ per\ capita_{jt}) + \beta_5(\ln\ \ \mathrm{Distance}_{ij}) + \beta_6 CA\_V2006 \\ & + \beta_7 CH_{L2009+\beta_8 CH_{V2006}} + \beta_9 L_{V2006} + \beta_{10} L_{T2008} + \beta_{11} river2012 \\ & + \beta_{12} tradezone2005 + \varepsilon_{ijt} \end{aligned} \qquad (8)$$

CA_V2006 is a dummy for road upgrading between Phnom Penh (Cambodia) and Ho Chi Minh City (Viet Nam) completed in 2006 along the Southern Economic Corridor. *CH_L2009* is a dummy for road upgrading between Kunming (PRC) and Houayxai (Lao PDR) completed by 2009 along the North-South Economic Corridor. *CH_V2006* is a dummy for the completion of the expressway by 2006 between Yougiguan border and Nanning along Eastern Economic Corridor 2. *L_V2006* is a dummy for the opening of the Hai Van tunnel and improvement of Da Nang port by 2006 along the East-West Economic Corridor. *L_T2008* is a dummy for the completion of the Second Mekong Friendship Bridge at the Savannakhet (Lao PDR)-Mukdahan (Thailand) border along the East-West Economic Corridor. In addition, *river2012* is a dummy for the opening of the second Cheang Saen port (Thailand) in 2012, which contributes to border trade between Thailand and the PRC along the North-South Economic Corridor, while *tradezone2005* is a dummy for the establishment of the border trade zone at the Ruili (Yunnan)-Muse (Myanmar) border in 2005 along the Northern Economic Corridor. Values for these dummy variables follow the criteria in Table 5.

We created panel data from the six GMS countries for the years 2000–2012. The data set suffers some contstraints due to missing data for Cambodia, Lao PDR, and Myanmar. Also, we faced the problem of inadequate partner-wise trade data for Yunnan province and the Guangxi Autonomous Region – at least reflected in their statistical yearbooks. Therefore, we substituted their trade data with the PRC's as a whole, which would make it somewhat difficult to interpret the results compared with using data taken from the seven economies of the GMS.

Descriptive statistics of the data set are provided in Table 9 (dummy variables are excluded).

Table 9: Descriptive statistics

Variable	Sample	Mean	Median	Max	Min	S.D.
X_GDP	390	10.81	10.46	15.94	7.42	2.31
M_GDP	390	10.81	10.46	15.94	7.42	2.31
X_PGDP	390	6.83	6.78	8.71	5.01	0.96
M_PGDP	390	6.83	6.78	8.71	5.01	0.96
DISTANCE	390	7.04	6.91	8.12	6.18	0.71
EL_INT	284	14.88	15.30	22.46	4.56	4.03
EL_FIN	284	14.66	15.29	22.38	3.66	4.15
TR_INT	253	13.79	14.92	20.30	3.00	3.87
TR_FIN	277	14.61	15.51	20.70	2.08	3.67

Source: Ono and Fujimura (2015).

X_GDP and M_GDP are GDP for the export and import country, respectively. X_PGDP and M_PGDP are per capita GDP for the export and import country, respectively. EL_INT and EL_FIN are pairwise trade value for intermediate and final goods, respectively, for electric machinery. TR_INT and TR_FIN are pairwise trade value for intermediate and final goods, respectively, for transport machinery. DISTANCE is the distance between the capitals of each pairwise trading partner country.

Despite some severe data constraints mentioned above, we were able to obtain somewhat reasonable results as shown in Table 10. The choice of the estimation model followed the results of the Hausman test. As a result, the intermediate goods trade in electric machinery applied a period fixed-effects model, and all the others applied a period random-effects model.

We obtained statistically significant coefficients with expected signs for almost all variables: positive for GDP and per capita GDP and negative for DISTANCE. The only anomaly is the negative and statistically significant coefficient for the GDP of the importing country in the trade in the final goods for transport machinery. We interpret this to be a reflection of some "PRC (as a large economy) bias." Our panel data, including trade values for the PRC as a whole instead of two southern provinces, may have led to this anomaly because small countries like Cambodia, Lao PDR, and Myanmar would mostly import final machinery goods from the PRC, not the other way round. The results could have been different if we had had pairwise trade data for the two provinces instead of the PRC as a whole.

Table 10: Estimation results from Model (6)
(Dependent variable = pairwise import value)

Explanatory Variables	Electric Machinery		Transport Machinery	
	Intermediate	Final	Intermediate	Final
X_GDP	1.061***	1.424***	0.990***	1.050***
M_GDP	0.437***	0.373***	0.343***	–0.218*
X_PGDP	1.563***	1.074***	1.594***	1.187***
M_PDGP	0.638***	0.730***	0.316	0.652***
DISTANCE	–0.457	–0.922***	–0.748*	–1.370***
Sample size	284	284	253	277
R^2	0.628	0.617	0.568	0.626

Source: Ono and Fujimura (2015).

When we added a dummy variable representing the development of all economic corridors in the GMS combined or INFRA, we obtained the results shown in Table 11. The choice of estimation model was the same as in Table 9. Here again almost all coefficients proved to have the expected sign and were statistically significant. The INFRA dummy obtained a positive and statistically significant coefficient for all trade categories, indicating that the development of economic corridors has had an overall intra-GMS trade-enhancing impact. In addition, the coefficient of the INFRA variable is greater for the intermediate goods than for the final goods in electric machinery but it is the other way around for transport machinery. This seems to reinforce the insight mentioned above that due to reduced service link costs through economic corridor developments, vertical integration across national borders in the GMS is more advanced for the electric machinery industry than for the transport machinery industry.

Table 11: Estimation results from Model (7)
(Dependent variable = pairwise import value)

Explanatory Variables	Electric Machinery		Transport Machinery	
	Intermediate	Final	Intermediate	Final
X_GDP	1.297***	1.458***	0.976***	1.030***
M_GDP	0.607***	0.390***	0.306***	–0.262**
X_PGDP	1.461***	1.059***	1.604***	1.166***
M_PDGP	0.637***	0.709***	0.330	0.638***
DISTANCE	–0.923	–0.965***	–0.637*	–1.241***
INFRA	1.063***	0.818***	0.867***	1.035***
Sample size	284	284	253	277
R^2	0.655	0.624	0.591	0.653

Source: Ono and Fujimura (2015).

Finally, we were not able to perform regressions on estimation Model 8 due to the lack of sample size relative to the increased number of explanatory variables – homework for the future with an improved data set.

We must reiterate some reservations about the above analyses. First, pairwise trade data for Cambodia, Lao PDR, and Myanmar are very much lacking. The UN Comtrade database, routinely used by researchers in empirical studies, fills the missing data for data-scarce countries through their trading partners with some adjustments. Analysis on intra-GMS trade like ours would face the same problem for the time being. In addition, we faced the problem of inadequate partner-wise trade data for Yunnan province and the Guangxi Autonomous Region. Substituting their trade data with the PRC's as a whole makes it somewhat difficult to interpret the results. Future studies need to collect the two provinces' detailed partner-wise trade data to improve on the analysis.

5. CONCLUDING REMARKS

This paper presented three approaches to the evaluation of cross-border transport infrastructure in the GMS. First, it presented partial attempts at benefit-cost ratios for the North-South, East-West, and Southern Economic Corridors. The estimates indicate that the economic viability seems to be in the order of the Southern, North-South, and East-West Corridors. The results for the Southern Corridor fit well with intuition from a gravity model framework, as the corridor involves the three large economies of Bangkok, Phnom Penh, and Ho Chi Minh City in a relatively short distance of about 900 km. In contrast, the East-West Corridor does not involve large economies (except Da Nang) along its route with a distance of about 1,450 km. The East-West Corridor presumably had a very long-term perspective at its conception. The results may well prove different in the time frame of 10−20 years. Numerous infrastructure developments are ongoing along these corridors, such as large bridges and port upgrading. Efforts to re-evaluate incorporating new developments with longer terms and more comprehensive data are warranted in the future.

Second, the paper presented a panel data analysis on how economic corridor developments have impacted living standards at subnational level. The results indicate that economic corridors in the GMS as a whole yielded an additional net positive impact. In addition, an interesting interpretation is possible that the impact of economic corridors may have shifted to the "dispersion" stage to some extent beyond the "agglomeration" stage.

Third, the paper presented a gravity model analysis on how economic corridors have affected intra-GMS trade through a presumed reduction in service link costs. The results indicate positive effects of the development of economic corridors on intra-GMS trade in intermediate goods, especially for electric machinery. This implies that cross-border transport infrastructure in the GMS has contributed to lower service link costs and facilitated vertical integration across borders in this industry.

While the second and third analyses are based on admittedly incomplete data and their rigor is not subject to question, it is hoped that these attempts stimulate the interests of researchers and practitioners working in similar areas.

Finally, it is worth noting that all the analyses presented in the paper are based on data related to only physical aspects of transport infrastructure and do not incorporate "soft" aspects of transport facilitation such as simplification of cross-border passage of goods and people and cross-border vehicle and driver licenses. These aspects are advanced under the Cross-Border Transport Agreement (CBTA) for the GMS. These are admittedly hard to quantify in a systematic manner, but, if included in analyses such as above, would presumably indicate an even more positive impact of the development of cross-border transport infrastructure.

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