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The Effect of Road Upgrading to Overland Trade in Asian Highway Network

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Abstract

This paper investigates an impact of road upgrading and improvement on overland trade in 18 out of 32 Asian Highway Network member countries. A regression based cost model was developed. The results indicate that approximately 6.5 billion US dollars is required to upgrade and improve surface condition of the selected roads with total length of 15,842 km. The gravity model approach was adopted to quantitatively evaluate overland trade expansion assuming pessimistic and optimistic scenarios: improvements in road quality indices up to 50 and up to 75, respectively. The results suggests that in the first scenario total intra-regional trade will increase by about 20 percent or 48.7 billion US dollars annually, while second scenario predicts that trade will increase by about 35 percent or 89.5 billion US dollars annually.

Keywords: *Asian Highway Network, road transport, gravity model.*

Jel Classification: *F12, F15, F17.*

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The views expressed in this paper are those of the author(s) and do not necessarily represent those of organizations the authors are associated with.

1. Introduction

In 1992, the United Nations Economic and Social Commission for Asia and the Pacific (ESCAP) endorsed the Asian Land Transport Infrastructure Development (ALTID) project comprising of the Asian Highway and the Trans-Asian Railway network. The formalization of the Asian Highway, through the Intergovernmental Agreement on Asian Highway Network (AHN), was adopted in November 2003. ESCAP member countries cannot afford the high costs of building a comprehensive network, therefore, the Asian Highway project was to be concentrated on the development and upgrading of existing regional highways among member countries (AHN, 2003). The Intergovernmental Agreement on the Asian Highway Network was adopted on 18 November 2003 by an intergovernmental meeting held in Bangkok, was open for signature in April 2004 in Shanghai and entered into force on 4 July 2005.

A large part of network about 82 percent is paved highways with two or more lanes. Approximately 7 percent of the total length is unpaved roads which are 10,000 in kilometers. Asian Highway routes from AH1 to AH9 are the routes which cross substantially more than one sub – region. These routes carry higher importance compared to other routes because they provide better transportation communications. There are four sub-regions such as South – East Asia, South Asia, Central and South – West Asia, and North – East Asia.

This paper examines the effect of road upgrading and improvement works to overland trade in 18 out of 32 member countries of Asian Highway Network. In order to estimate the cost of upgrading and improvement works in countries of the Asian Highway project, a regression model was developed using the World Bank's ROCKS (Road Costs Knowledge System) database. This database contains unit cost data of various highway projects from more than 80 developing countries around the world. The database contains the unit cost of road projects, the project type, pavement characteristics, terrain and climate, collected over a period of time. We utilize the gravity model approach to quantitatively evaluate overland trade expansion taking into account road quality improvements with two scenarios: improvement of road quality by 50% and by 75%.

2. Regression Based Cost Model

Regression models have proven their usefulness for decades now since they can be invaluable in quantitative estimations and explaining relationship between dependent and independent variables. The regression models are not panacea for all needs, however. If not properly taken into consideration, econometric problems such as multicollinearity, heteroscedasticity and endogeneity can make estimations biased. The details of these issues are well described in literature (Lewis-Beck M. 1980, William D et al., 1985, Brikes D et al. 1993, Allison S et al., 1999, Miles J et al., 2001, Frank E. 2001).

One of the ways to mitigate some of the problems is a logarithmic transformation of dependent and independent variables. We have decided to use the logarithmic transformation partly due to ease of interpretation (Carroll J et al., 1988).

We use the regression model to estimate the unit cost of road upfrading. For that, we postulate that unit cost (UCij) is a function of country's GDP (Gi), country's road network density (RNDi), pavement width (PW), country's annual mean precipitation (APi), coastline divided by area of the country (DLi), project type (PTi) and region (RGi) defined as follows:

$$\log UC_{ij} = \alpha_0 + \alpha_1 \log G_i + \alpha_2 \log RND_i + \alpha_3 \log PW + \alpha_4 \log AP_i + \alpha_5 DL_i + \sum_j \gamma_j RG_j + \sum_j \beta_j PT_j + \varepsilon_{ij}$$

(1)

where the symbols have the following values and meanings:

UCij = unit cost of project type j in country i (USD 2004/km)

Gi = GDP per capita of country i(USD 2004,PPP)

RNDi = road network density of country i(km per 1000 km^2)

PW = pavement width (m)

APi = annual mean precipitation of country i(mm)

DLi = coastline divided by area of country i(km per 1000 km^2)

PTi = dummy variable for project type

RGi = dummy variable for region

The coefficients and *t* statistics of our road cost models are shown in Table 2. The results suggest that a 1% increase in GDP per capita leads to a 0.08% decrease in unit cost. A 1% increase in road network density leads to a 0.06% increase of unit cost. An increase in pavement width by 1% yields a 0.28% increase in unit cost. The adjusted R^2 is equal to 0.9. To prevent perfect multicollinearity, one class in each dummy-variable set was dropped.

Table 1: Unit Cost Determinants

Dependent Variable: Log Project Unit Cost (USD/km)	Coefficients	t stat
Log GDP Per Capita (G)	-0.08	-2.64*
Length of coastline divided by area (DL)	1.92	2.54*
Log Annual Mean Precipitation (AP)	-0.10	-2.65*
Log Road Network Density (RND)	0.06	2.69*
Log Pavement Width (PW)	0.28	3.02*
Asphalt Overlay 40 to 59 mm (PT1)	-3.50	-6.27*
Asphalt Overlay 60 to 79 mm (PT2)	-3.20	-5.70*
Asphalt Overlay 80 to 99 mm (PT3)	-2.81	-5.04*
Asphalt Overlay < 40 mm (PT4)	-3.94	-7.00*
Asphalt Overlay > 99 mm (PT5)	-2.55	-4.56*
Double Surface Treatment (PT6)	-4.51	-8.02*
Fog Seal (PT7)	-5.92	-10.52*
Heavy Grading (PT8)	-8.39	-13.91*
Light Grading (PT9)	-9.92	-16.93*
New Bituminous 2L Highway (PT10)	-0.77	-1.37
New Bituminous 4L Expressway (PT11)	-0.26	-0.43
New Bituminous 4L Highway (PT12)	-0.14	-0.24
New Concrete 4L Highway	-0.83	-1.44
New Concrete 2L Highway (PT13)		
New Unsealed 1L Road (PT14)	-2.91	-4.58*
New Unsealed 2L Highway (PT15)	-4.33	-5.51*
Partial Widening to Bituminous 2L (PT16)	-2.65	-4.49*
Partial Widening to Bituminous 2L and Reconstruction (PT17)	-2.30	-4.09*
Partial Widening to Unsealed 2L and Reconstruction (PT18)	-4.64	-7.21*
Regravelling (PT19)	-5.31	-9.49*
Routine Maintenance 1L Road (PT20)	-8.44	-10.64*
Routine Maintenance Bituminous 2L Highway (PT21)	-6.76	-11.88*
Routine Maintenance Block 2L Highway (PT22)	-6.65	-9.74*
Routine Maintenance Unsealed 2L Highway (PT23)	-7.67	-12.74*
Reconstruction Bituminous (PT24)	-2.50	-4.49*
Reconstruction Concrete (PT25)	-2.38	-4.06*
Reconstruction Unsealed (PT26)	-3.99	-7.07*
Spot Regravelling (PT27)	-9.82	-12.44*
Slurry Seal or Cape Seal (PT28)	-5.29	-9.32*
Single Surface Treatment (PT29)	-4.94	-8.80*
Upgrading Block to Bituminous 2L Highway (PT30)	-2.14	-3.15*
Unsealed Preventive Treatment (PT31)	-6.27	-11.08*
Upgrading Unsealed to Bituminous 2L Highway (PT32)	-2.28	-4.07*
Upgrading Unsealed to Concrete 2L Highway (PT33)	-2.15	-3.34*
Upgrading Unsealed to Unsealed 2L Highway (PT34)	-3.88	-6.76*
Widening Adding Bituminous 1L and Reconstruction (PT35)	-2.21	-3.90*
Widening Adding Bituminous 2L (PT36)	-0.54	-0.85
Widening Adding Bituminous 2L and Reconstruction (PT37)	-1.08	-1.89**
Africa (RG1)	0.02	0.33
Asia (RG2)	-0.07	-1.01
Caribbian-Central-America (RG3)	0.16	1.61
East Asia-Pacific Islands (RG4)	-0.16	-1.85**
Europe - Middle East (RG5)		
South America (RG6)	0.15	1.82**
Intercept	15.43	21.7
Observations	1385	
Adj. R Squared	0.90	
* t statistics significant at 1%,** at 5%		

2.1. Predicting Upgrading and Improvement Works Costs

The AHN database contains information of the routes for 18 countries out of 32, including road surface condition, pavement type, terrain and other (AHND, 2004). Table 2 shows route condition and design standard in each country. From this table it can be observed that about 15,842 km need to be improved or upgraded in order to provide good transportation communications.

Table 2. Road surface condition and design standards in ESCAP member countries

No.	Country	Route No.	AH Design Standard / Surface Condition	Total Length (km)
1	Armenia	AH81, AH82, AH83	Class III or Higher / Bad	386
2	Bangladesh	AH1, AH2, H41	Below Class III	450
3	Cambodia	AH11	Below Class III	198
4	China	AH3, AH32, AH42	Below Class III	542
5	Georgia	AH81, AH82	Class III or Higher / Bad	55
6	India	AH1, AH 2	Below Class III	75
7	Iran	AH1, AH8, AH70, AH72, AH75, AH78, AH82	Class III or Higher / Bad	1084
8	Kazakhstan	AH7, AH61, AH62, AH63, AH70	Below Class III	897
9	Kyrgyzstan	AH7, AH61, AH65	Below Class III	370
10	Lao	AH3 , AH11, AH12, AH13, AH15, AH16	Below Class III	656
11	Mongolia	AH3, AH4, AH32	Below Class III	3486
12	Nepal	AH 42	Below Class III/Bad	34
13	Pakistan	AH2, AH4, AH7, AH 51	Below Class III / Bad	3144
14	Russia	AH4, AH6, AH7, AH8, AH30, AH31, AH60/61/70	Below Class III / Bad	3640
15	Tajikistan	AH7, AH65, AH66	Below Class III	343
16	Thailand	AH1, AH15, AH16	Class III or Higher / Bad	68
17	Uzbekistan	AH63	Below Class III	224
18	Vietnam	AH14, AH15	Below Class III	190
	Total			15842

Road surface condition and design standards in countries like Japan, South Korea, Singapore, Malaysia, and Turkey are in good condition and satisfy Asian Highway design standards. Data for countries like Democratic People's Republic of Korea, Turkmenistan, Bhutan, Azerbaijan and Indonesia are found partially or not available therefore they were dropped from analysis.

To estimate the cost of improvements and upgrading in above – mentioned table 3, we used earlier mentioned cost regression equation (1). The results of predicted cost of these upgrading and improvement works are displayed in Table 4.

Table 3. Predicted cost of upgrading and improvement works

No.	Country	Pavement Width (m)	Road Upgrade/Improvements	Expected Output	Total Length (km)	Total Cost (million US $ 2002)
1	Armenia	6 - 7	Reconstruction Bituminous	Improved Condition	138	23.3
		7 -14	Reconstruction Bituminous	Improved Condition	248	47.4
2	Bangladesh	< 4.5	Widening Adding Bituminous 2L and Recon	Class II	100	57.5
		4.5 – 6	Widening Adding Bituminous 1L and Recon	Class II	350	76.0
3	Cambodia	4.5 – 6	Widening Adding Bituminous 1L and Recon	Class II	198	112.6
4	China	< 4.5	Upgrading Unsealed to Bituminous	Class II	67	10.5
		4.5 – 6	Upgrading Unsealed to Bituminous	Class II	475	87.4
5	Georgia	6 – 7	Reconstruction Bituminous	Improved Condition	55	7.5
6	India	< 4.5	Widening Adding Bituminous 2L and Recon	Class II	75	44.1
7	Iran	7 – 14	Reconstruction Bituminous	Improved Condition	1,042	199.7
		6 – 7	Reconstruction Bituminous	Improved Condition	42	7.1
8	Kazakhstan	6 – 7	Upgrading Unsealed to Bituminous	Class II	743	153.4
		< 4.5	New Construction 2L Highway	Class II	154	147.2
9	Kyrgyzstan	7 – 14	Upgrading Unsealed to Bituminous	Class I	370	91.4
10	Lao	7 – 14	Reconstruction Bituminous	Condition Improvement	244	42.4
		6 – 7	Reconstruction Bituminous	Condition Improvement	44	6.8
		6 – 7	Upgrading Unsealed to Bituminous	Class II	292	55.8
		6 – 7	New Construction 2L Highway	Class II	76	65.7
11	Mongolia	< 4.5	New Construction 2L Highway	Class II	3,070	2,431.5
		< 4.5	Upgrading Unsealed to Bituminous	Class II	416	57.1
12	Nepal	4.5 – 6	Widening Adding Bituminous 1L and Recon	Class II	26	5.2
		6 – 7	Reconstruction Bituminous	Condition Improvement	8	1.3
13	Pakistan	< 4.5	Widening Adding Bituminous 2L and Recon	Class II	1,174	736.0
		6 – 7	Reconstruction Bituminous	Condition Improvement	1,042	196.5
		7 – 14	Reconstruction Bituminous	Condition Improvement	928	198.4
14	Russia	7 -14	Upgrading Unsealed to Bituminous	Class II	882	188.4
		6 - 7	New Construction 2L Highway	Class II	89	77.6
		< 4.5	New Construction 2L Highway	Class II	876	764.3
		7-14	Reconstruction Bituminous	Condition Improvement	1,793	307.8
15	Tajikistan	< 4.5	New Construction 2L Highway	Class II	48	46.2
		6 - 7	Upgrading Unsealed to Bituminous	Class II	278	57.8
		7 -14	Upgrading Unsealed to Bituminous	Class II	17	4.0
16	Thailand	> 14	Reconstruction Concrete	Condition Improvement	40	7.6
		6 -7	Reconstruction Bituminous	Condition Improvement	18	2.3
		> 14	Reconstruction Bituminous	Condition Improvement	10	1.7
17	Uzbekistan	7 -14	Upgrading Unsealed to Bituminous	Condition Improvement	224	56.5
18	Vietnam	4.5 - 6	Widening Adding Bituminous 1L and Recon	Class II	53	9.6
		< 4.5	Widening Adding Bituminous 2L and Recon	Class II	137	65.7
	Total				15,842	6,451.3

Total cost of upgrading and improvement works for 15,842 km in 18 countries would cost about 6.4 billion US dollars. Figure 1 depicts the highway routes (thick red line) that are belong to upgrading and road improvements in AHN. These routes play vital role in trade between Asia and Europe.

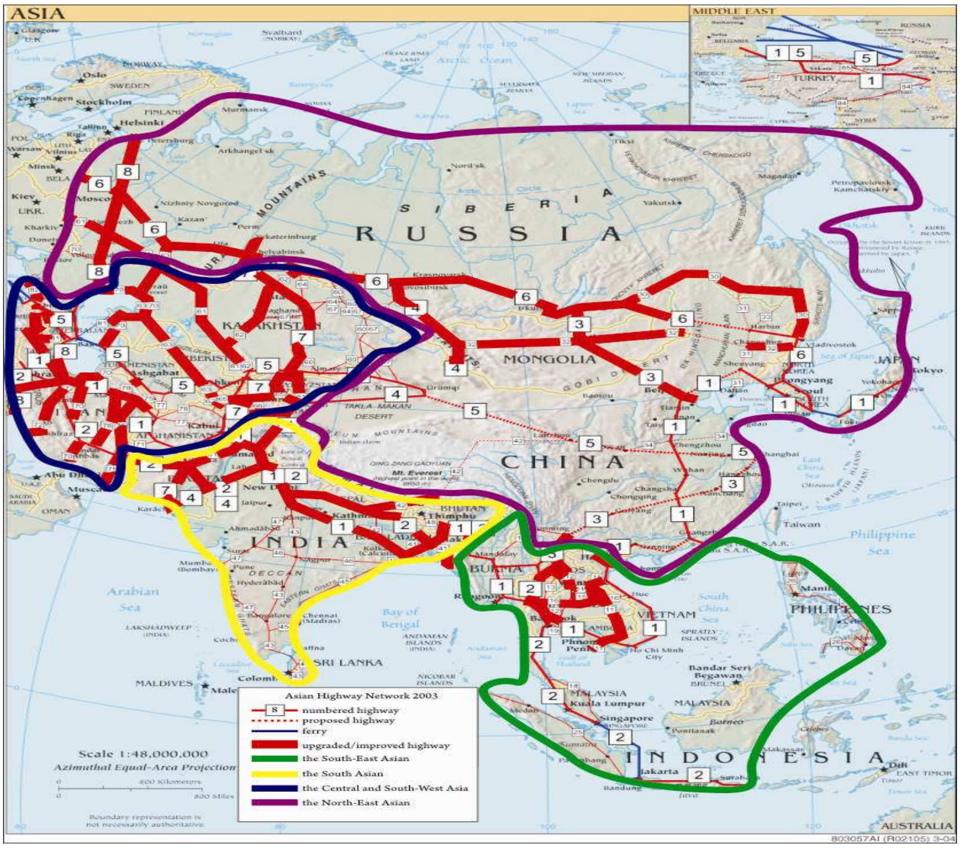


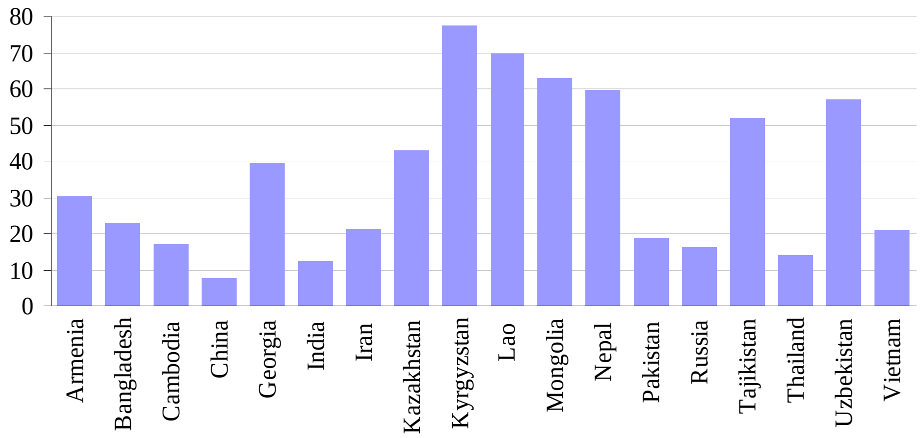
Figure 1. AHN Routes that Require Upgrade and Improvement (AHND, 2004)

3. Quantitative Assessment of Trade

3.1. Intra-Regional Trade

Although 18 continental countries have enormously increased their overall trade over the past several decades, intra-regional trade was still only 12 per cent of their total trade in 2005. Figure 2 shows the ratio of intraregional trade[1] to overall trade for countries in our sample. The share varies wildly, between 7.7 percent for China to 77 percent for Kyrgyzstan. There are two facts worth noting from the graph. First, the share of intra-regional trade for small countries is much higher than for big countries. This is consistent with overall tendency for big countries to be less open than small countries. Second, Former Soviet Union countries have much higher intra-regional trade on average. This can be attributed to the legacy of Soviet Union with its close trade and production networks among countries.

Figure 2 Share of intra-regional trade in total trade, % (2005)



There are many reasons for relatively low levels of intra-regional trade in continental Asia. Political and historical tensions certainly have played a role, as well as the attractiveness of North American and European markets as a destination for exports products and source of technological imports.

But unfavorable geographical factors and low quality of transport infrastructure have also impaired intra-regional trade to a great extent. Vast and difficult terrain,

[1] Intra-regional trade is defined as trade among 18 countries in our sample.

especially in the inner part of the Asian continent, has made overland trade among continental countries much less profitable. Due to the lack of adequate level of transport infrastructure, shipping goods from one country to another in the region through overland transport networks might be more expensive than shipping from the region to North America and Europe through sea transport.

4.2. The Gravity Model Approach

This paper adopts a gravity model approach to study the impact of AHN road upgrade on trade. The gravity model originally stems from Newtonian physics, which simply states that the attraction between two physical objects is proportional to their masses, but inversely related to the distance between them. This paradigm has long been disregarded by economists due to its lack of theoretical foundation. However, due to successive works of various economists, it has been gradually developed into a systematic economic model with a strong economic foundation. Anderson (1979) derived the gravity equation from monopolistic competition setting. Helpman and Krugman (1985) showed that the basic gravity equation could be derived from the differentiated products trade. It is a theory that suggests that flows of goods depend on the demand in the importing country and the supply of differentiated products from the exporting country. Deardorff (1995) showed that the gravity model is also consistent with Hecksher-Ohlin international trade theory.

The gravity model has also been extensively utilized in empirical economic literature. Thus it was applied in estimation of bilateral trade flows, FDI flows, and equity flows. For example, Frankel (1997) used the gravity model approach to explain the factors affecting the formation of trade blocs. In his standard gravity model, bilateral trade was explained by variables such as GNP, per capita GNP, distance, adjacency, language, and trading blocs. Gravity models have also been used to explain determinants of FDI and equity flows. Kawai and Urata (1998) used a gravity model to investigate the relationship between trade and FDI using Japanese data at the industry level. FDI and trade were found to be generally complementary to each other. Portes and Rey (2000) also adopted a gravity model to study factors affecting equity flows among 14 developed economies. Their empirical results demonstrated that market size, openness, efficiency of transactions, and distance are the most important determinants of bilateral equity flows.

In recent years gravity model has increasingly been utilized in analyzing the impact of infrastructure on trade. Majority of studies show that transportation infrastructure quality has significant and robust impact on overall transport costs.

Notable examples include Redding and Venables (2004), Limao and Venables (2001), Coulibaly and Fontagné (2004), Martínez-Zarzoso and Nowak-Lehmann (2006), Buys, Deichmann and Wheeler (2006), Shepherd and Wilson (2006) and others.

In particular, Redding and Venables (2001) use a ratio of roads to area as a proxy for quality of infrastructure and find that low infrastructure quality is the main factor behind low trade in Sub-Saharan Africa. Coulibaly and Fontagné (2004) study determinants of trade in countries belonging to the West African Economic and Monetary Union and find that paving all inter-state roads would increase trade by a factor of 3, and crossing a transit country reduces bilateral trade flows by 6%. Buys, Deichmann and Wheeler (2006) first estimate the costs of initial upgrading Sub-Saharan interstate road network as 20 billion dollars and 1 billion dollars as cost of annual maintenance. Then they proceed to estimate the potential beneficial impact of continental road network upgrading on overland trade as about 250 billion USD over 15 years. Limão and Venables (2001) estimate that poor infrastructure account for 40 percent of transport costs for coastal countries and 60 per cent for landlocked countries.

In all of these studies the gravity model framework serves as a workhorse to estimate impact of infrastructure upgrading on trade. The attractiveness of the gravity model is that it allows us to address the specific questions in mind with regard to both the fundamental economic and institutional determinants of trade in continental Asia. First, what are the fundamental determinants of trade? Are traditional variables of gravity models such as economic size, distance, tariff and common border significant explanatory variables? Second, does infrastructure quality matter in facilitating trade between among Asian countries? This paper offers some quantitative simulations to illustrate how the improvement of transport infrastructure and reduction of tariff barriers can stimulate trade and economic development.

3.3. Econometric Specification and Data Description

Following the empirical literature, we specify a simple version of gravity model for total trade, exports and imports. In each specification GDP variable enters the trade regression in a product form. As a result, the gravity model for total trade takes the following form:

$$LnT_{ijt} = \alpha + \beta_1 Ln(Y_{it}Y_{jt}) + \beta_2 Ln(D_{ij}) + \beta_3 B_{ij} + \beta_4 Tar_i + \beta_5 Tar_j + \beta_6 R_i + \beta_7 R_j + \mu_{ijt} \quad (2)$$

where T_{ijt} indicates trade between country i and country j at time t, Y_{it} and Y_{jt} are real GDPs of country i and j, representing economic mass, D_{ij} is distance between capital cities and B is a common border dummy, Tar_i and Tar_j are tariff rates in country i and j, respectively. Finally, R_i and R_j represent road quality indexes in country i and j, respectively. As it is standard in trade literature, i represents a reporting country, while j is a partner country.

Vast trade literature predicts expected signs and sometimes magnitudes of coefficients in equation (2). In particular, theory predicts that larger economic mass is associated with higher volumes of trade. Distance, as a proxy for transportation cost, is expected to have a negative sign. Common border dummy is expected to have a positive sign. Trade is expected to have a negative relationship with tariff barriers and a positive relationship with road quality index.

Distance, calculated as a surface distance between capital cities according to latitude and longitude (Wall, 1999; Raballand, 2003; Rose and Wincoop, 2001), is considered as proxy for transportation cost in a borderless world. Border effect is expressed by inclusion of common border dummy (Rose and Wincoop, 2001; Rose, 2002; Breuss and Egger, 1999; Frankel and Rose, 2001). The problem with simple great circle distance variable is that it does not fully capture high transportation costs due to natural geographical location of landlocked and remote countries. Transportation costs are usually affected by border delays (type of a non-tariff barrier). To capture this peculiar feature of transportation cost we also include common border dummy variable. Following Raballand (2003) we assumed for two coastal countries there is a one border, and only for landlocked countries this variable is equal to one.

But even with distance and common border dummy variables, one cannot be sure that she takes into account all complexities of transportation costs. One of the most important factors for overall transportation costs is the quality of transport infrastructure. Usually, the higher the quality of infrastructure the lower is the transportation costs and higher incentives for trade. Bougheas et al (1999) utilized stock of public capital and length of motorway network and predicted a positive relationship between the level of infrastructure and the volume of trade. Limao and Venables (2001) developed unique infrastructure composite index, as a total infrastructure stock (roads, paved roads, telephones and railway networks) divided by the total population. But they excluded all transition economies in FSU and Europe due to missing data for own and transit infrastructure. Unfortunately, lack of data for Asian countries made calculation of composite index impossible. Instead, we utilized road quality index as an additional.

The model is estimated for 18 Asian countries over the period 1995-2004. Aggregate bilateral trade data are from International Monetary Fund's Direction of

Trade Statistics (DOTS) database. Data on GDP are taken from World bank's World Development Indicators (WDI) database. Weighted average tariff rates are taken from Trade Analysis and Information System (TRAINS) database, maintained by The United Nations Conference on Trade and Development (UNCTAD). Except dummy variables, all variables are in logarithmical form.

4. Results and Discussions

Table 4 shows estimation results. We consecutively estimate equations for trade, imports and exports. In the trade regression we follow Baldwin and Taglioni (2006) and use the product of real GDP.

Table 4 Gravity model estimations

Dependent variable	**Trade**	**Exports**	**Imports**
Product of GDP	1.06	1.05	1.02
	[0.02]**	[0.02]**	[0.02]**
Distance	-1.63	-1.66	-1.42
	[0.07]**	[0.07]**	[0.08]**
Common border dummy	1.40	1.36	1.62
	[0.12]**	[0.14]**	[0.13]**
Road quality index of country i	-0.06	0.16	-0.16
	[0.08]	[0.07]*	[0.09]
Road quality index of country j	0.44	-0.06	0.79
	[0.08]**	[0.09]	[0.09]**
Average tariff rate of country i	-0.23	-0.04	-0.37
	[0.05]**	[0.05]	[0.05]**
Average tariff rate of country j	-0.20	-0.31	-0.15
	[0.04]**	[0.04]**	[0.05]**
Constant	-35.64	-34.85	-37.04
	[0.77]**	[0.78]**	[0.90]**
Observations	2069	1920	1917
R-squared	0.74	0.72	0.67

Robust standard errors in brackets

* significant at 5%; ** significant at 1%

The gravity model fits the data well and produces theoretically correct and economically significant coefficients. As expected, the coefficients of real GDP are statistically significant, slightly above 1 in all specifications. The coefficient of distance is negative, highly significant. In elasticity terms it shows that 1 percent increase in distance is associated with a -1.65 percent decline in trade and exports, and around 1.42 percent decrease in imports. Common border dummy is also highly significant and positive. The point estimates of common border dummy indicates that if countries share common border, they trade with other 4 times more (exp(1.4)=4.05). This effect is even stronger for imports. The coefficient of common border dummy indicates that there is a lot of potential to increase overland trade, especially between countries with common borders.

The coefficients of tariff rates are negative and statistically significant, and their magnitude ranges from -0.15 to -0.37. Trade equation indicates that, say, 10 percent reduction in tariff rates increase overall trade by about 2 percent. Taking into account that in most instances tariffs are already quite low and they cannot be drastically decreased, it becomes clear that further reductions of tariff rates among continental Asian countries have limited impact on trade.

On the other hand, the road quality index shows that a good transport infrastructure can greatly facilitate trade. In particular, the positive coefficient of road quality index for country j in trade regression – 0.44, which is statistically highly significant[2], indicates that improvement of the quality of overland roads can boost trade significantly. For example, if Nepal improves quality of its roads index from 31 to 50 (48 percent improvement in logarithmic terms), it can expect its overall trade increase by 21 percent (0.48 multiplied by 0.44), or by 285 million US dollars annually.

A word of caution should be voiced regarding the coefficient of road quality index for exports and imports equation. While in exports equation it is not statistically significant, in the imports equation it is significant both statistically and of sizable magnitude. A point estimate of 0.79 shows that 1% improvement in the road quality index leads to almost 0.8% increase in the volume of imports. This asymmetric impact of road quality upgrade on exports and imports can pose certain problems for balance of payments in these countries. But taking into account that the countries under consideration run huge current account surpluses, the likely impact of this asymmetry will be relatively small.

Based on the gravity model estimations, we can estimate the impact of road quality upgrading on intra-regional trade. Table 5 shows the results of this exercise under two scenarios: pessimistic and optimistic. Under pessimistic scenario it is assumed that major road improvement efforts will upgrade road quality index to 50 percent throughout the region. It is pessimistic scenario because it assumes that major routes surface conditions will be improved without any upgrading. Armenia, Georgia, Iran, and Thailand already have road quality grade of 50, so it is assumed that they will not benefit directly in terms of trade expansion due to road improvement.

[2] We can ignore road quality index of country i, since it is not statistically significant in all three regressions

In the case of Uzbekistan, whose baseline road quality index is 25, upgrading it to 50 (nearly 70 percent improvement on a logarithmic scale) will increase the trade by 940 mln USD or 30%[3].

Table 5. Net Effect of Road Upgrading on Trade

Country	Road Quality Index	Inter-regional trade in 2004, mln US dollars	Net Effect of Road Upgrading, mln US dollars	
			Scenario 1 (up to 50%)	Scenario 2 (up to 75%)
Armenia	50.0	530.4	-	94.6
Bangladesh	25.0	4139.53	1,262.5	2,001.0
Cambodia	25.0	819.74	250.0	396.3
China	25.0	81683.26	24,912.1	39,484.8
Georgia	50.0	881.01	-	157.2
India	25.0	20066.49	6,120.0	9,699.9
Iran	50.0	15022.54	-	2,680.1
Kazakhstan	25.0	14964.24	4,563.9	7,233.6
Kyrgyzstan	25.0	1436.8	438.2	694.5
Lao	36.0	1022.67	148.1	330.6
Mongolia	25.0	1042.75	318.0	504.1
Nepal	30.9	1343.58	284.9	524.6
Pakistan	40.7	4103.05	373.1	1,105.1
Russia	37.3	41246.66	5,311.0	12,669.6
Tajikistan	25.0	1021.1	311.4	493.6
Thailand	50.0	24352.18	-	4,344.5
Uzbekistan	25.0	3147.66	960.0	1,521.5
Vietnam	25.0	11461.15	3,495.5	5,540.2
Total		228284.8	48,748.6	89,475.7

Scenario 2 assumes more ambitious criterion, namely, continental Asian countries upgrade their interstate road quality to 75. In terms of AHN classification, Table 6 shows the net impact of road improvement on trade under two scenarios. Under Scenario 1 the total intra-regional trade will increase about 20 percent to 48.7 bln US dollars annually, while Scenario 2 predicts that trade will increase by about 35 percent to 89.5 billion US dollars annually. The main beneficiaries of the road improvement will be China, Russia, India, and Vietnam smaller countries will also benefit from overall increase in trade due to the improvement in transport infrastructure.

[3] The figure arrived by multiplying the road quality coefficient in trade equation in Table 4 (0.44) by the logarithmic measure of improving the road quality index from 25 to 50 (0.69). The resulting 0.30 or 30% then is equivalent to the increase in annual trade volume by 960 mln USD.

5. Conclusions

We estimated cost of upgrading and improvement works costs of sub-network of AHN using World Bank's ROCKS database. This provided initial perspective on the size of lumpy investment required to improve road condition in AHN. It was estimated that approximately 6.5 billion US dollars is required to upgrade roads and improve existing surface condition of the selected sub-network with total length of 15,842 km of AHN. The gravity model approach explained how big the trade expansion will increase. The net impact of road improvement on trade under two scenarios was considered. In scenario 1, the total intra-regional trade will increase about 20 percent to 48.7 bln US dollars annually, while Scenario 2 predicts that trade will increase by about 35 percent to 89.5 billion US dollars annually. The main beneficiaries of the road improvement will be China, Russia, India, and Vietnam smaller countries will also benefit from overall increase in trade due to the improvement in transport infrastructure. Priority of road upgrading in each country is suggested to be carried out in a way that first road condition improvements need to be done after that upgrading to higher class necessary to carry out. But it must also fit to each country's network strategic plan. The results show that road quality is positively associated with trade, while tariff rates are negatively correlated with trade. These results are consistent with transportation economics viewpoint that road upgrading decreases transportation costs such as vehicle operation cost (fuel consumption, spare, etc) and user cost (travel time). Higher traffic volumes allow the policymakers to take advantage the higher trade volumes and decrease tariff rates further. Future research will focus on trade expansion among all AHN member countries taking into account other modes of transportation.

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