PRELIMINARY ROAD COST STUDIES IN DEVELOPING COUNTRIES

Lecturer JAMSHID SODIKOV
Tashkent Automobile and Road Institute,
20, street Movounnahr,Tashkent, 100020
Advisor Economist
ZIYODULLO PARPIEV
UNDP Uzbekistan Country Office

Abstract: *In the early estimation there is compromise between the amounts of information available and accuracy of estimation. We propose three levels of analysis such as regional, country and project level for road cost models in order to provide efficient data usage. The data for our research was obtained from the World Bank's ROCKS database, which contains unit costs for road projects from over 80 developing countries. This paper investigates the impact of road upgrading and improvement works on overland trade in 18 out of 32 member countries of Asian Highway Network. The results indicated 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. The gravity model approach was adopted to quantitatively evaluate overland trade expansion taking into account road quality improvements with two scenarios such as road quality increases up to 50% in the first scenario in the second one up to 75%. The results suggests that in the first scenario total intra-regional trade will increase about 20 percent to 48.7 billion US dollars annually, while second scenario predicts that trade will increase by about 35 percent to 89.5 billion US dollars annually.*

Key words: *Construction costs - Maintenance costs - Developing countries -Regression models*

I. INTRODUCTION

1.1 Backgrounds and problem statements

The available cost data on highway projects in developing countries are generally limited in numbers, incoherent and contain a large amount of incomplete data. Limited financial resources and lack of systematic cost data collection are also the major problems which affect cost database quality. These factors negatively affect to cost estimators and planners to make appropriate decisions. Accurate cost estimation in early project development is an impor tant issue where detailed information is not available and project costs are to be decided, in most cases cost estimating relationship techniques are used. One of the challenges is accurate cost estimation during pre-feasibility studies.

Most research studies on cost estimation early stage of project were conducted using data from developed countries (Healey, 1964; Sanders et al., 1992; Pearce et al., 1996; Smith et al., 1997; Hegazy et al., 1998; Adeli et al., 1998; Al-Tabtabai et. al., 1999; Morcous et al., 2001; Flyvbjerg et al., 2002, Emsley et al., 2002; Levinson et. al., 2003; Trost et al., 2003; Gwang-Hee et. al., 2004). Very limited number of research has been done in developing countries (Archondo-Callao et al., 2004; Buys et al., 2006). One of the major reasons for a few numbers of researches is related to cost database availability in developing countries. Initial steps to build cost database for developing countries was initiated by the World Bank's Transportation Unit in 1999 and ROCKS (Road Costs Knowledge System) was introduced. Cost data collected from developing countries all around the world and this system has large amount of incomplete data in some data items. This explains the need to examine and analyze the cost estimation techniques and how to deal with missing data in developing countries context which is the primary objective of this study. Additionally, due to nature of available data in the ROCKS database efficient data usage has been introduced by level of analysis which is also incorporated in this study.

Road agencies, contractors, consultants and financial institutions need road costs information, which usually is locally available, but in many case it is scattered and collected in unsystematic ways. These entities need to assess costs differences, but no framework to compare road costs exists. In 1999, in response to this demand, the World Bank made the first attempt to collect this information from 67 Implementation Completion Reports of Bank – financed projects that were implemented in the period 1995 – 1999. The study found that the level of detail provided in these types of documents was limited and that there is a worldwide need for a framework to collect this type of information in 2000. Consequently, the Bank decided to develop a simple system to collect road costs and to explore other sources of information. This effort resulted on the ROCKS, which is being developed by the World Bank's Transport Unit and is primarily based on the experience of Bank staff and the information contained in roads and highways projects in developing countries.

1.2 Concept of level of analysis

Concept of level of analysis was evolved from cost model application perspective and existing data availability. As mentioned earlier that ROCKS database contains missing data, the task is to utilize available data in efficient way which assists to develop better cost model with certain application purpose. These application purposes can be defined as cost estimation study in a given geographical region, cost study within a certain country and finally cost estimation of a specific project with detailed information. It is generally known that detailed information is limited in regional cost studies especially during preliminary cost studies. This is due to each country in particular region has certain amount of cost history data which vary among countries. In some countries there may be more project details are available in others limited project details are available, in some extreme case there may be no cost history database at all. In order to balance available data amount (project details and number of projects) with cost model application purposes, three level of analysis were proposed such as:

Regional level – cost model is developed based on limited project details with large number of observations

Country level – cost model is developed based on relatively detailed project information with comparatively smaller number of observations

Project level – cost model is developed based on in depth project details with limited number of observations

Regional level of analysis – ROCKS database was divided into 6 regional subsets for regional level of analysis namely Africa, Asia, Caribbean-Central-Middle America, East Asia-Pacific Islands, Europe-Middle East, South America region. From figure 1 it can be observed that large number of projects belong to Africa with 29%, Asia with 24%, and Europe-Middle East with 19%. Total number of projects consists of 1385 from 85 countries

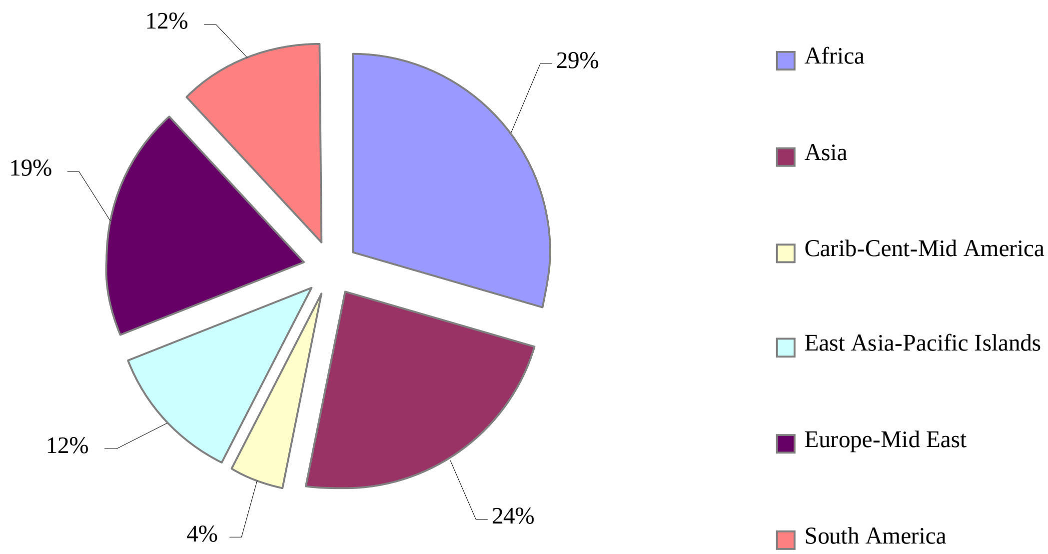


Figure 1. *Regional Level Project Distributions (World Data)*

Average unit cost of work activities among these regions varies significantly. For instance new construction projects in Africa region on average is about one million US dollars per km but in Europe-Middle East on average new project is about one and half million US dollars per km.

Although number of observation is quite large but available data items are limited. These data items are workactivity and pavement width in ROCKS. The other data items such as GDP per capita, annual mean precipitation, road network density, coastline divided by area are collected from external sources to build cost model for regional level of analysis.

Country level of analysis include additional data items to regional level of analysis from ROCKS such as rate of work per area which obtained by dividing work duration to pavement area and contractor type. But number of observation has dropped from 1385 to 318. Additional data items are available only for Armenia, Ethiopia, Ghana, Kyrgyz Republic, Lao PDR, Nigeria, Poland, and Uganda. Distribution of projects in each country is shown in figure 2. Countries with large number of projects are Ghana, Uganda, Poland, and Lao PDR.

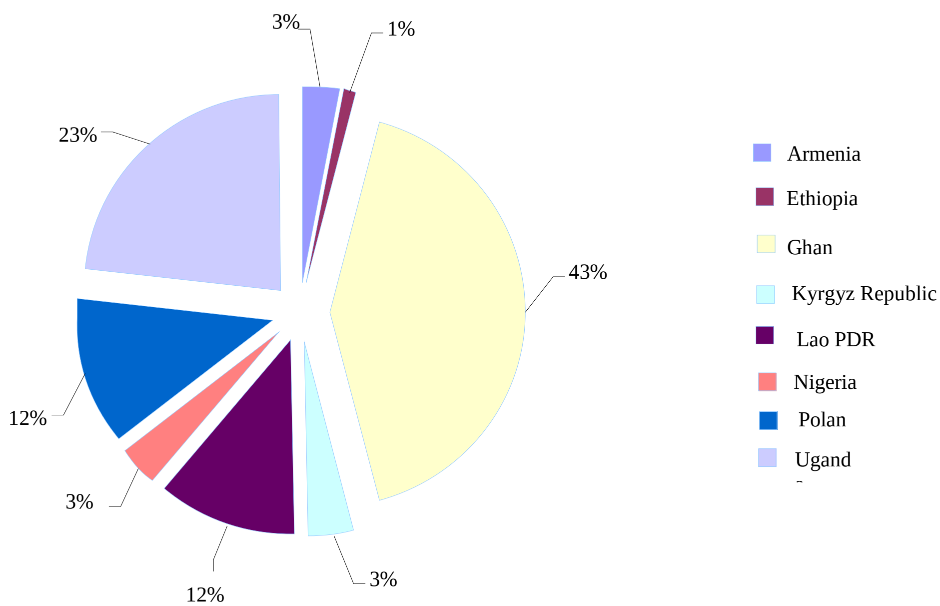


Figure 2. *Country Level Project Distributions*

Project level of analysis includes additional data items to country level of analysis from ROCKS such as terrain type, climate and surface thickness data. But number of observation has dropped from 318 to 56. Additional data items are available only for Kyrgyz Republic, Lao PDR, and Nigeria. Distribution of projects in each country is shown in figure 3. The largest number of projects belongs to Lao PDR.

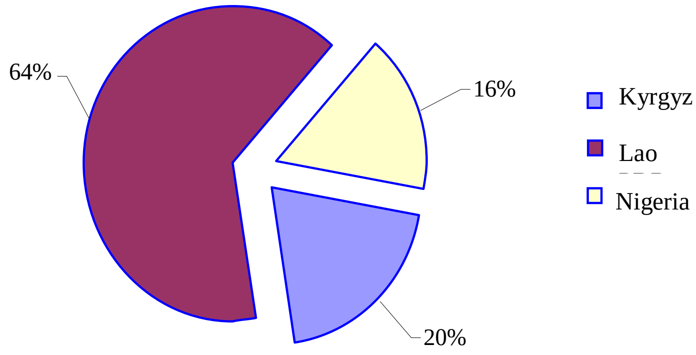


Figure 3. *Project Distributions at Project Level*

Data for project level of analysis is very limited in terms of number of observation but project specific data such as terrain, climate data and surface thickness are available. Only three countries have these data for bituminous reconstruction and partial widening bituminous with 2 lanes with reconstruction projects.

II. COST MODELS

2.1. Regression cost models

Regression models have been proven to be reliable and used for decades. There are some advantages of regression models such as they can be defined by mathematical expression and explain relationship between dependent variable and independent variables. There are also some disadvantages in regression models such as multicollinearity, nonlinearity, heteroscedasticity and other issues which occur in regression model development. 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 powerful techniques to overcome shortcoming of regression models is transformation dependent or independent response or both. Several types of data transformation were tested and log-log transformation was chosen for our analysis. The advantage of log-log transformation lies on ease of interpretation (Carroll J et al., 1988).

At regional level 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:

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

where the symbols have the following values and meanings:

UC_{ij} = unit cost of project type j in country i (US $ 2004/km)

G_i = GDP per capita of country i(US $ 2004,PPP)

RND_i = road network density of country i(km per 1000 km2)

PW = pavement width (m)

AP_i = annual mean precipitation of country i(mm)

DL_i = coastline divided by area of country i(km per 1000 km2)

PT_i = dummy variable for project type

RG_i = dummy variable for region

At country level we postulate that unit cost (UC_{ij}) is a function of country's GDP (G_i), country's annual mean precipitation (AP_i), coastline divided by area of the country (DL_i), rate of work per area (RW), project type (PT_i) and contractor (CTR_j) defined as follows:

$$\log UC_{ij} = \alpha_0 + \alpha_1 \log G_i + \alpha_2 \log AP_i + \alpha_3 DL_i + \alpha_4 \log RW + \sum_j \beta_j PT_j + \sum_j \gamma_j CTR_j + \varepsilon_{ij}$$

where the symbols have the following values and meanings:

UC_{ij} = unit cost of project type j in country i (US $ 2004/km)

G_i = GDP per capita of country I (US $ 2004, PPP)

RW = Rate of work per area (Work duration divided by pavement area)

AP_i = annual mean precipitation of country i (mm)

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

PT_i = dummy variable for project type

CTR_j = contractor type

At project level we postulate that unit cost (UC_{ij}) is a function of country's GDP (G_i), rate of work per area (RW), surface thickness (PST), terrain (TR_j), climate (CL_j), project type (PT_i) and contractor (CTR_j) defined as follows:

$$\log UC_{ij} = \alpha_0 + \alpha_1 \log G_i + \alpha_2 \log RW + \alpha_3 \log PST + \sum_j \beta_j TR_j + \sum_j \gamma_j CL_j + \sum_j \lambda_j CTR_j + \sum_j \varphi_j PT_j + \varepsilon_{ij}$$

where the symbols have the following values and meanings:

UC_{ij} = unit cost of project type j in country i (US $ 2004/km)

G_i = GDP per capita of country i(US $ 2004,PPP)

RW = rate of work per area (Work duration divided by pavement area)

PST = pavement surface thickness (mm)

TR_j = dummy variable for terrain type

CL_j = dummy variable for climate

CTR_j = contractor type

PT_i = dummy variable for project type

III. CASE STUDY

3.1. The asia highway network

The AHN covers routes which cross 32 member countries with approximate total length of 140,000 km. It starts from Japan, Tokyo, and extends to Finland, Helsinki and Bulgaria, Sofia. The network passes mostly through existing roads in those countries. Asian Highway Design standards comprise of Primary, Class I, Class II, and Class III highway classifications which are defined according to terrain classification, design speed, width (including right of way, lane, shoulder, median strip), minimum radii of horizontal curve, pavement and shoulder slope, type of pavement, maximum superelevation and grade, and structure loadings (AHNDS, 2004). Table 1 highlights recommended design standards for Asian Highway routes. The minimum requirement which satisfies the Asian highway network standard is the Class III. According to Asian highway standards, it is suggested that the Class III should be applied only when the funding for the construction or land for constructing road is limited. There are two priorities in which the Asian highway network member countries have to carry out, 1) To improve road conditions where it is necessary in Primary, Class I, Class II and Class III which cover 72% of total network, 2) to upgrade the rest 28% of network at least to the Class III but preferably to Class II.

Table 1. *Asian highway standards (AHNDS, 2004)*

Highway classification		Primary (4 or more lanes)				Class I (4 or more lanes)				Class II (2 lanes)				Class III (2 lanes)			
Terrain classification		L	R	M	S	L	R	M	S	L	R	M	S	L	R	M	S
Design speed (km/h)		120	100	80	60	100	80	50		80	60	50	40	60	50	40	30
Width (m)	Right of way	(50)				(40)				(40)				(30)			
	Lane	3.50				3.50				3.50				3.00 (3.25)			
	Shoulder	3.00		2.50		3.00		2.50		2.50		2.00		1.5 (2.0)		0.75 (1.5)	
	Median strip	4.00		3.00		3.00		2.50		N/A		N/A		N/A		N/A	
Min. radii of horizontal curve (m)		520	350	210	115	350	210	80		210	115	80	50	115	80	50	30
Pavement slope (%)		2				2				2				2 - 5			
Shoulder slope (%)		3 – 6				3 – 6				3 – 6				3 - 6			
Type of pavement		Asphalt/cement concrete				Asphalt/cement concrete				Asphalt/cement concrete				Dbl. bituminous treatment			
Max. superelevation(%)		10				10				10				10			
Max. vertical grade (%)		4	5	6	7	4	5	6	7	4	5	6	7	4	5	6	7
Structure loading (minimum)		HS20-44				HS20-44				HS20-44				HS20-44			

The AHN database contains information of the routes for the most of the countries, which is about 18 countries out of 32, these information include 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

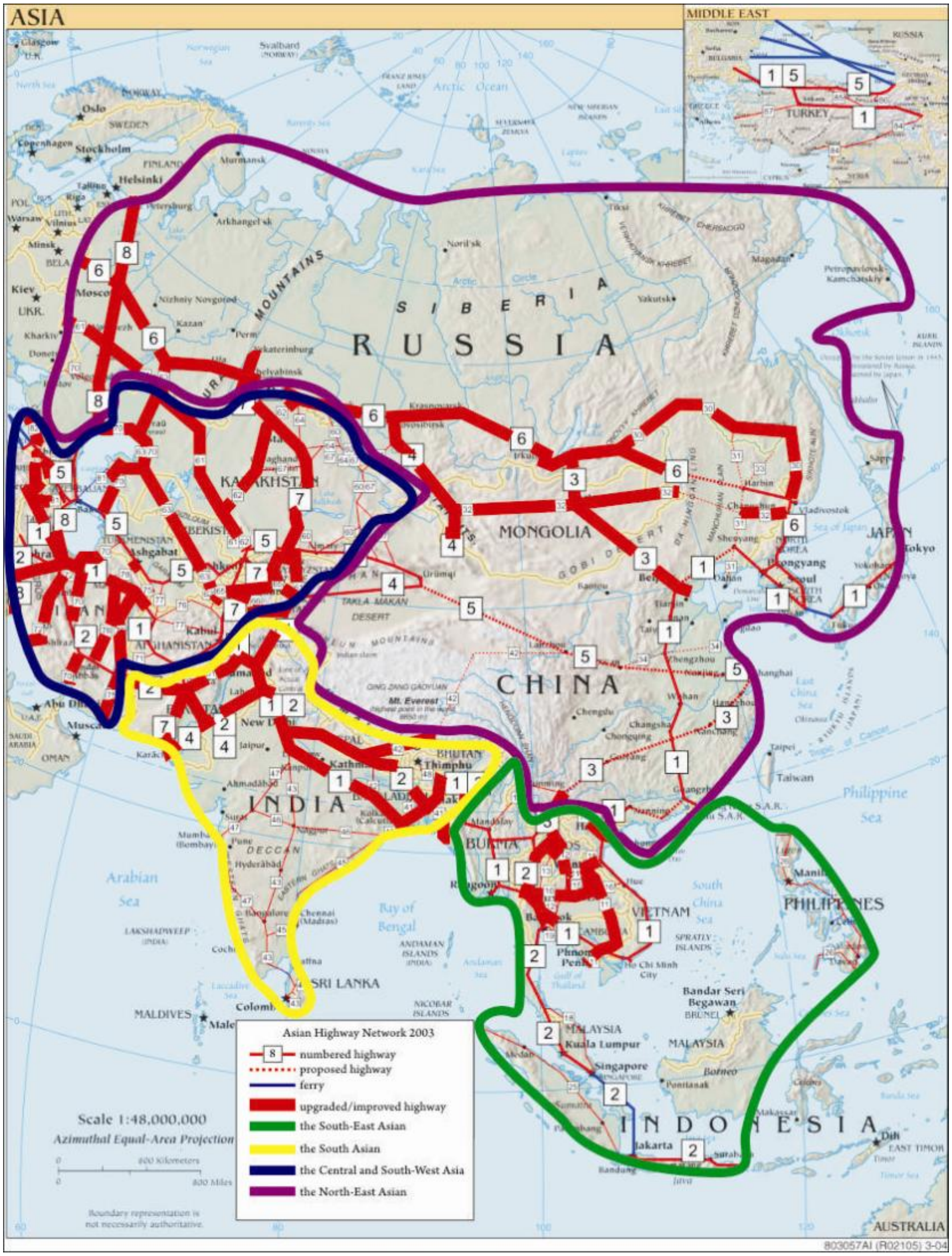
Road surface condition and design standards in the following countries like Japan, South Korea, Singapore, Malaysia, and Turkey are in good condition and satisfy Asian Highway design standards. Data for countries like Democratic People's Republic of Korea, Turkmeni stan, Bhutan, Azerbaijan and Indonesia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

To estimate the cost of improvements and upgrading in above – mentioned table 2, we used regression cost model at a regional level of an alysis. The results of predicted cost of these upgrading and improvement works are displayed in Table 3.

Table 3. *Predicted cost of upgrading and improvement work*

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 4 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.



3.2 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 5 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.

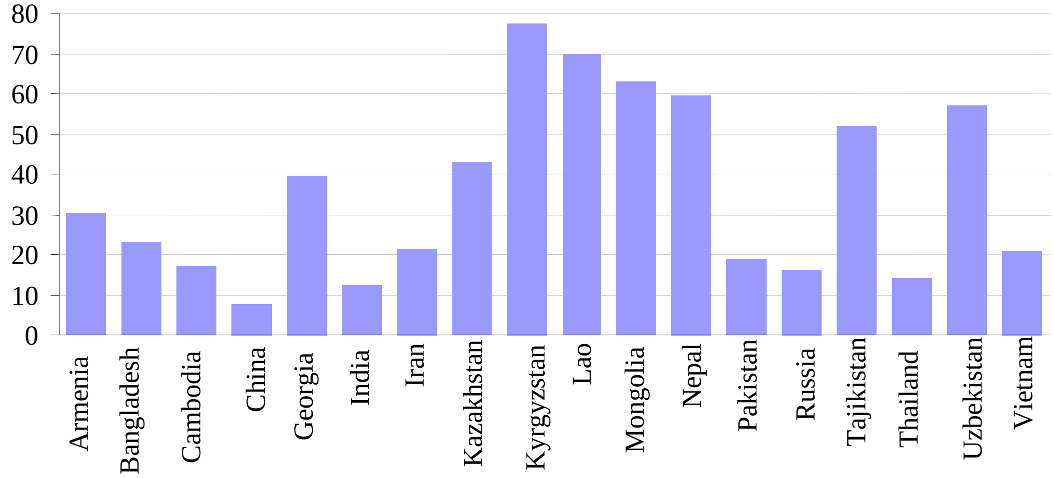


Figure 5. *Share intra-regional trade in total trade, % (2005)*

There are numerous 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, 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.

3.3. 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

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

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 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 econo mic development

3.4. 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 ma ss, 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.

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 t o 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 Wincoo p, 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 countri es 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 i mportant 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 p ublic 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 19 Asian countries over the period 1995 -2004. Aggregate bilateral trade data are from International Monetary Fund's Direction of Tr ade 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 Conf erence on Trade and Development (UNCTAD). Except dummy variables, all variables are in logarithmical form.

3.5 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 w ith 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 tra de 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 tha t 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 in trade regression – 0.44, which is statistically highly significant, 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 mill ion US dollars annually.

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 sc enario 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.

Scenario 2 assumes more ambitious criterion, namely, continental Asian count ries upgrade their interstate road quality to 75. In terms of AHN classification, Table 5 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 d ollars 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 o verall increase in trade due to the improvement in transport infrastructure.

__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

IV. CONCLUSION

Introduction level of analysis shed light on issue like efficient data usage in existing database. It is important to mention that missing data is almost unavoidable part of data collection process. So when some of the data times are missing then the common approach is to use available data. We recommended to separate data items in ROCKS in accordance to level of analysis such as regional, country and project level to utilize available data efficiently. In regional level, the purpose was to select plausible data items with the largest number of observations which later were used for cost model development. In case of project level, the aim was to select data items which represent project details in depth therefore number of observations were very limited. Country level analysis lies in between regional and project level of analyses and contains some of regional level data items as well as project level data items which lead to utilize more data with some project details in cost model development.

Regression cost models are widely used because they are easy and relatively fast to implement, various well-documented procedures are available, and finally cost estimators prefer to use regression models rather than analytical tools such neural networks because regression models are well defined and mathematically explained whereas neural network works much more like black box.

It was estimated cost of upgrading and improvement works costs of sub -network of AHN using World Bank's ROCKS database. This provided initial perspec tive 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 als o 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 h igher 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.

Reference

[1]. *Adeli H. and Wu M.* Regularization neural network for constru ction cost estimation, Journal of Construction Engineering and Management, ASCE 124(1), pp 18 -24, 1998

[2]. *Allison S., Allison D***.** Multiple Regression: A Primer. Forge Press. 1999

[3]. *Al-Tabtabai, H., Alex, A., and Tantash, M.* Preliminary Cost Estimati on of Highway Construction Using Neural Networks, Cost Engineering, Association for the Advancement of Cost Engineering, Morgantown, WV. 41(3), 19-24, 1999

[4]. *Archondo-Callao R., Bhandari A.* Road Costs Knowledge System – ROCKS – Version 2.2, User Manual, World Bank, 2004

[5]. *Anderson, J.E.A*. 1979. A theoretical foundation for the gravity model. American Economic

Review, Vol. 69, pp. 106–16.

[6]. *Andrew K. Rose & Eric van Wincoop*, 2001. "National Money as a Barrier to International Trade: The Real Case for Currency Union," American Economic Review, vol. 91(2), pages 386 -390, May.

[7]. Asian Highway Network Handbook, United Nation, New York, 2003.

[8]. Asian Highway Design Standard, UNESCAP, 2004

http://www.unescap.org/ttdw/common/tis/ah/AnnexII -E.pdf. Accessed: June 10, 2008

[9]. Asian Highway Network Database (AHND), UNESCAP, 2004 http://www.unescap.org/ttdw/common/tis/ah/Member%20countries.asp Accessed: June 10, 2008

[10]. *Bunke, O and B. Droge*. Bootstrap and cross-validation estimates of prediction error for linear regression models. Ann. Stat. 12, 1400-1424, 1984

[11]. *Baldwin, Richard, and Daria Taglioni* (2006). "Gravity for Dummies and Dummies for Gravity Equations," NBER Working Papers 12516

[12]. *Bougheas, Spiros, Panicos O. Demetriades and Edgar L.W. Morgenroth* (1999), "Infrastructure, Transport Costs and Trade", Journal of International Economics, Vol. 47, 169-189.

[13]. *Breuss, Fritz, and Peter Egger* (1999), "How Reliable Are Estimations of East-West Trade Potentials Based on Cross-Section Gravity Analyses?", Journal Empirica 26 (2), 81-94

[14]. *Brikes D, Birkes D, Dodge Y*. Alternative Methods of Regression. Wiley-Interscience. 1993

[15]. *Buys, Piet, Uwe Deichmann and David Wheeler* (2006), Road Network Upgrading and Overland Trade Expansion in Sub-Saharan Africa, World Bank Policy Research Working Paper 4097, December

[16]. *Carroll J, Raymond J, Ruppert D***.** Transformation and Weighting in Regression. CRC Press. 1988.

[17]. *Coulibaly and Fontagné* (2005), South-South Trade: Geography Matters, Journal of African Economies, Vol. 15, Number 2, pp. 313-341

[18]. *Deardorff, A.V*. (1998). Determinants of Bilateral Trade: Does Gravity Work in a Neoclassical World?, in: J. Frankel (ed.), The Regionalization of the World Economy. University of Chicago Press.

[19]. *Emsley M, Lowe D., Duff A, Harding A, Hickson A*. Data Modeling and the application of a neural network approach to the prediction of total construction cost. Journal of Construction Management Economy, 20, pp.465-72, 2002

[20]. *Frank H.* Regression Modeling Strategies: with Applications to Linear Models, Logistic Regression and Survival Analysis. Springer. 2001

[21]. *Frankel, Jeffrey A*. (1997). Regional Trading Blocs in the World Economic System, Institute for International Economics, Washington, D.C.

[22]. *Frankel, Jeffrey, and Andrew Rose* (2000). "An Estimate of the Effect of Currency Unions on Trade and Growth," for a Conference on Currency Unions, organized by Alberto Alesina and Robert Barro, Hoover Institution, Stanford University, May 19-20.

[23]. *Flyvbjerg B. H., Mette S., and Buhl S*. Underestimating costs in public works projects, error or lie, Journal of the American Planning Association, Vol. 68, No.3, pp 279-292, 2002

[24]. *Geisser, S*. The predictive sample reuse method with applications. Journal of American Statistics Association, 70, 320-328. 1975

[25]. *Gwang-Hee K, Sang-Hoon A, Kyung-In K*. Comparison of construction cost estimating models based on regression analysis, neural networks, and case-based reasoning. Journal Building and Environment. Vol. 39, pp 1235-1242, 2004

[26]. *Healey, J. M*., "Errors in Project Cost Estimates," Indian Economic Journal, Vol. 12, July- Sept. 1964.

[27]. *Hegazy T. and Ayed A*. Neural network model for parametric cost estimation of highway projects, Journal of Construction Engineering and Management, ASCE 124(3), pp 210-218, 1998

[28]. Helpman, *E. and Krugman, P.R*. (1985). Market structure and foreign trade. Increasing returns, imperfect competition, and the international economy, MIT Press, Cambridge, MA

[29]. *Kawai, Masahiro and Shujiro Urata* (1998), "Are Trade and Investment Substitutes or Complements? An Empirical Analysis of Japanese manufacturing Industries," in Lee, Hiro, Roland and W. David, Economic Development and Cooperation in the Pacific Basin: Trade, Investment, and Environmental Issues, Cambridge; New York and Melbourne: Cambridge Univers ity Press, 1998.

[30]. *Levinson, D. and Karamalaputi*, Ramachandra. Predicting the Construction of New Highway Links. Journal of Transportation and Statistics Vol. 6(2/3) 81–89, 2003

[31]. Lewis-Beck M. Applied Regression: An Introduction. Sage Publication Inc. 1980.

[32]. *Miles J., Shevlin M*. Applying Regression and Correlation: A Guide for Students and Researchers. Sage Publication Inc. 2001.

[33]. *Limão, N. and Venables, A.J*. (2001), "Infrastructure, Geographical Disadvantage, Transport Costs and Trade", World Bank Economic Review, 15, 451-479.

[34]. *Martínez-Zarzoso and Nowak-Lehmann* (2006), Is Distance a Good Proxy for Transport Costs? The Case of Competing Transport Modes, CeGE-Discussion Paper 54, May

[35]. *Pearce A. R., Gregory, Rita A., and Williams L*. Range Estimating for risk management using artificial neural networks, Journal of Parametric Estimating, 14(1), pp 88 -93. 1996

[36]. Portes, Richard and Hélène Rey (2000). "The Determinants of Cross-Border Equity Flows: The Geography of Information," Center for International and Development Economics Research (CIDER) Working Papers C00-111, University of California at Berkeley

[37]. *Raballand, G*. (2003). The determinants of the negative impact of land-lockedness on trade: an empirical investigation through the Central Asian case. ROSES, University of Paris 1, mimeo May 2003.

[38]. *Redding, S., Venables, A. J*. 2004. Economic geography and international inequality. Journal of International Economics, 62(1): 53-82.

[39]. ROCKS, Road Costs Knowledge System (v. 2.2), (The World Bank, Transport Unit – TUDTR), 2004. http://www.worldbank.org/transport/roads/rd_tools/rocks_main.htm . Accessed June 10, 2008

[40]. *Rose, A.K*. 2002. Do WTO members have more liberal trade policy? NBER Working Paper #9273

[41]. *Sanders, S., and Maxwell, R*., "Preliminary Estimating for Heavy Construction," AACE Transactions, Association for the Advancement of Cost Engineering International, Morgantown , WV, 1992.

[42]. Stone, M. Cross-validatory choice and assessment of statistical predictions. Journal of the Royal Statistical Society. Series B (Methodological), Vol. 36, No.2. pp. 111 -147. 1974

[43]. *Shepherd, Ben, and John S. Wilson* (2006), Road Infrastructure in Europe and Central Asia: Does Network Quality Affect Trade? World Bank Policy Research Working Paper 4104, December 2006

[44]. *Trost, S. , and Oberlender, G*. Predicting accuracy of early cost estimates using factor analysis and multivariate regression. Journal of Construction Engineering Management, Vol. 129, No. 2, 2003, pp. 198 -204.

[45]. *William D., Stanley F*. Multiple Regression in Practice. Sage Publications Inc. 1985

[46]. *Wall, Howard J*. (1999). "Using the gravity model to estimate the costs of protection,"Review, Federal Reserve Bank of St. Louis, issue Jan, pages 33 -40♦