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EMPIRICAL ANALYSIS OF MULTIPLE INFRASTRUCTURAL COVARIATES: AN APPLICATION OF GRAVITY MODEL ON ASIAN ECONOMIES

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ABSTRACT

This study assesses the simultaneous influence of hard and soft infrastructural indicators on exports in 46 Asian states from 2001 to 2017 with panel data. We constructed two main aggregate indicators such as hard infrastructure and soft infrastructure with fifteen primary or sub-group variables. The infrastructural aggregate indicator contains four groups: transportation, communication, and financial infrastructural and border-transport efficiency. These indicators are taken into account in estimating the influence on export levels and probability between bilateral Asian trading partners by using factor analysis, the augmented gravity model and the two-stage sample selection model. Findings show that simultaneous improvement in hard infrastructure such as transport and telecommunication improved bilateral exports. Similarly, simultaneous improvement in soft infrastructure like financial infrastructure and border-transport efficiency increased bilateral exports in Asian countries. For both export and import, the coefficients of infrastructural indicators have a positive impact and are statistical significant at each econometric scale. Improving financial infrastructure is important in achieving a higher level of trade volume and increasing the probability of exporting between partners. We also examine the evidence on the complementarity or substitutability between hard and soft infrastructure as captured by indicators which shows us that main aggregate indicators have a lower impact on exports.

Contribution/ Originality: This study is one of very few studies to investigate the influence of hard and soft infrastructural indicators on exports in sense of indicator substitutability or complementarity in different dimensions such as transportation, communication, and finance and border-transport efficiency. Improving soft infrastructure is complementary to establishing hard infrastructure between bilateral trading partners.

1. INTRODUCTION

Internationally, the trade environment is pinioned with infrastructure. Challenges in trade and infrastructure can cause trade impediments such as increased transportation costs due to issues with hard and soft infrastructure. Examining the effectiveness of infrastructure on trade has been become important in studies examining the trade performance of countries and regions. A multidimensional concept of infrastructure affects not just trade but also

economic growth, social welfare, resource efficiency, innovation, economic development and other economic outcomes. Therefore conceptualizing, classifying and analyzing infrastructure has been a key focus of prior research.

Martin and Rogers (1995) defines any facility that provided by the state (like goods, institution, and law and order) that connects production to consumption is called public infrastructure. Additionally, Bouet *et al.* (2008) states that quantifying the true impact of infrastructure on trade however is difficult mainly because of the interactive nature of different types of infrastructure. The impact of greater telephone connectivity depends upon the supporting road infrastructure and vice versa. Expanding infrastructure can reduce transportation costs and alter the comparative advantages of a country and also cause a huge disintegration of production supply chains' potential including increasing the country's intraregional trade.

De (2008) states that bilateral trade would be increased by 10 percent due to reductions in tariff and transportation costs by 2 percent and 6 percent respectively. Hence, comparatively trade volume's propensity is higher with the reduction of transportation costs than with tariff costs. Infrastructure is key in moving goods from origin to destination. It controls the trade costs and the system has qualitative and quantitative infrastructural values within a country and its region. Low infrastructural quantity and quality adversely affects trade and economic growth.

Asia is an important economic region to establish an infrastructure connectivity network. It has a heterogeneous infrastructure network due to different geographical, cultural, social, political and economic characteristics that differentiate parts of the infrastructural connectivity network. Both hard and soft infrastructure such as transportation, communication, financial and border-transport efficiency are necessary for trade. Less attention to soft infrastructure leads to inefficient hard infrastructure and failure to achieve trade goals. Deficiency in transaction services and border matters adversely affects trade and disappoints the traders. Consequently, a country's trade performance drops.

Therefore, this study assesses the simultaneous effect of hard and soft infrastructure on trade in Asian economies that would be able to identify the issues of their trading systems. This study also examines the financial services and border activities with the traditional infrastructural variables of transportation and telecommunication in the trade system of all Asian economies. Literature suggests that previously, only transportation and telecommunication have been examined without simultaneously assessing financial and border activities to determine trade performance.

We examine the data regards to the finance and border sectors of the economy, and ask if, based on how exporter and importer countries infrastructure impact on exports level, there is any relationship of gross domestic product and export levels to infrastructural indicators and how do traditional gravity variables affect export levels and infrastructure with respect to hard and soft infrastructure?

We estimate the effect on trade in the region by constructing main aggregate indicators. There are two dimensions of infrastructure: hard infrastructure related to tangible infrastructure such as roads, railways, ports, internet servers, mobile subscriptions, fixed subscriptions and broadband subscriptions; and soft infrastructure such as time to export, time to import, documents to export, documents to import, Automatic transaction machine (ATM), deposit accounts, point of sale (POS) and merchants. Each dimension contains four sub variables such as communication, financial and border-transport efficiency rather than transportation infrastructure.

We constructed four aggregate indicators related to hard and soft infrastructure from primary variables using statistical modeling techniques such as principal components analysis and factor analysis. To estimate correlation among the observed factors through an unobserved common factor, it is relatively more rigorous and a less arbitrary procedure to derive the aggregate indicators than average out primary variables. Though PCA is similar to FA it has a more refined technique underlying the analytical model. Unobserved factors determined the observed primary indicators based on the factor analysis's assumptions.

The two indicators closely related to hard infrastructure are transportation and communication. The two indicators closely related to soft infrastructure are financial infrastructure and border-transport efficiency. The indicators for 46 Asian countries over the period 2001-2017 and fifteen primary variables were derived and collected from different international organizations and sources namely the World Development Indicators (WDI), the Payment System of World Bank, the United States Nation UNSPC, CEPII and the World Trade Organization (WTO).

This paper is divided into three parts: the first is a review of previous literature on infrastructure, the second constructs the infrastructure indicators and the third lists the empirical results and discussions.

The methodology is based on two steps. The first step is in creating the main aggregate indicators of hard and soft infrastructure by pulling together all the relevant primary variables for each dimension The next step involves constructing indicators separately such as transportation infrastructure, telecommunication infrastructure, financial infrastructure and border-transport efficiency and including seventeen primary variables. In addition to assessing the impact of different aspects related to infrastructure (measured by indicators) on exports by implying a gravity model, this study also covers more data and dimensions about both hard and soft infrastructure and impacts as shown in econometric technique gravity type models[1].

We used the latest econometric technique to estimate the model. However, we used a two stage sample selection model (Heckman, 1979); (Helpman *et al.*, 2008) to deal with a potential bias due to a firm level of heterogeneity and a sample selection bias due to country pairings that did not trade with each other[2].

Two stage strategies also explain the extensive and intensive margins in assessing the export levels. Findings show that reforms in infrastructure could improve the export volume of growing economies at the extensive margin and intensive margin. Improving the quality and quantity of transport infrastructure, communication infrastructure and border-transport efficiency could increase the trade volume at a particularly intensive margin.

We examined the potential reverse causality of exports to infrastructure by adding a new variable measuring at different scales, cannot affect the export volume establishing the hard and soft infrastructure. We also discuss omitted multilateral resistance effects following a procedure explained by Baier and Bergstrand (2009) to correct multilateral resistance variables and consider the multilateral resistance effect.

For the robustness check[3], we applied different estimation methods and restricted the sample to trade in infrastructure. We incorporated the interaction terms of infrastructural indicators and economic size (GDP) to test the simultaneous effect or distinguished impact of infrastructural indicators on exports. Evidence shows that the hard infrastructural impact on export levels seems beneficial while financial infrastructure shows the reverse due to inefficient financial systems in poor countries. For further analysis, we added interaction terms of both hard and soft

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[1] For instance, Santos and Silvana (2006,2011); Helpman, Melitz and Rubinstein (2008) & Martin and Pham (2008).

[2] We implied the Probit model to estimate the probability that bilateral exports occur at above the average in the first stage. And also implied gravity regression augmented by two terms in second stage. The first term corrects the selectivity that is computed from the first stage and second inverse Mills ratio to correct potential bias due to unobserved firm level heterogeneity. To imply of Heckman model on our sample, variable that identification influence the probability of exporting but volume is not required to conform with excluding the restriction.

[3] To robustness check, we perform different econometric techniques such as principal component, iterative reweight least square and quantile regression to derive the infrastructural indicators, give weights to indicators and minimum the value of sum of absolute residual respectively. When including alternative indicators in baseline model, we do not have expected signs and procedure derive indicators using factor analysis to deal better correlation between the variables. For IRLS and QR explanation results available upon request.

infrastructure to test the substitutability or complementarity between both types of infrastructure. The results show that there is complementarity existing in both types of infrastructure (hard and soft).

2. OVERVIEW OF PREVIOUS WORK

This section describes the previous research on infrastructure and trade in several regions. Broadly the literature shows that assessing the exact impact of infrastructure on trade still remains a challenge. The wide estimation range found in the literature may be due to some factors like relevant geographical characteristics, interrelations of different infrastructure types, infrastructure capacity utilization and study characteristics.

Additionally, there are challenges in definitions of infrastructure. (Bouet *et al.*, 2008) states that "measuring the influence of infrastructure on trade is challenging due to interactive nature of different infrastructure's kinds. However, any greater impact of telephone connectivity depends upon the supporting road infrastructure and vice versa. Therefore, infrastructure effects can be non-linear as well as need to be explored through taking account of several infrastructural interactions including types.

Additionally Portugal-Perez and Wilson (2012) considered infrastructural possibility 'satiation' based on conclusions from 101 countries as a sample. The results show that the enhancement of infrastructural impact on export performance reduces per capita income.

However, in rich countries information and communication technology is progressively effective. Donaubauer *et al.* (2018) assessed the impact of infrastructure on bilateral trade for a large sample of 150 developed and emerging economies. Their results show that improvement in infrastructure endowments and quality reduces trade costs and enhances trade flows. This improvement in infrastructure encourages multilateral trade cost reduction too. The effects of decomposition indicate that high export levels are encouraged by better infrastructure than domestic trade flows. Additionally, Donaldson (2018) shows that development in the railroad setup period from 1853 to 1930 in colonial India connected the individual district with the rest of India and the world, and improved the country's trading environment and welfare. Also, transaction cost reduction, increment in productivity and access to markets exist due to the development of highways for the United States; Datta (2012) India and Peru. Allen and Arkolakis (2014) discuss how geographical information regarding locational characteristics such as rail, road and water networks of the United States determine trade costs and account for twenty percent of the spatial welfare distribution across the US.

In assessing the impact of infrastructure on trade, another question arises of asymmetry in bilateral trade. For this purpose, Martínez-Zarzoso and Nowak-Lehmann (2003) estimate the bilateral trade flows in the EU-Mercosur economies. Their results indicate that investing in a trade partner's infrastructure is not valuable because trade is increased by the exporter's infrastructure and the result is not universal. However, Limao and Venables (2001) state that all dimensions of infrastructure have a positive impact on bilateral trade flows, even though they examine exporter, importer and transit countries' infrastructure separately. Also Grigoriou (2007)'s results show that road construction within a noncoastal state may not be sufficient to increase trade since transit country infrastructure. Bargaining power with transit countries and transport costs also play a vital role in trade performance.

Additionally, for those trade partners who have diverse economic characteristics, the impact of infrastructure may not be symmetric. For instance, Longo and Sekkat (2004) estimate that there are key roles for both importer and exporter infrastructure in intra-African trade flows. However, their estimation couldn't calculate important infrastructure influence concerning trade flows between Africa and developed countries. Njinkeu *et al.* (2008)'s study on intra-African trade proposed that improving the infrastructure of ports and services seem to be adding more benefits in improving trade performance in the region than any other procedures. Another issue arises that a specific part of infrastructure in any geographical part of an economy may impact the infrastructure on exports and imports at another location within the same economy differently. Two locations relatively far apart may produce unreliable outcomes due to the spatial unit of measurements so an analysis of smaller spatial units may be beneficial.

However, the study of the impact of infrastructure on trade at a sub-national level is very rare. Wu (2007) concludes that there is positive impact between infrastructure and trade performance using infrastructural measures such as total length of highways per square kilometer of regional area in Chinese regions.

Similarly, another sub-national level study, Granato (2008) assessed trade performance in Argentinean regions with regards to 23 partner countries. Results suggest that for regional export performance, regional infrastructure and transportation costs are very important determinants. Trade researchers measured infrastructure in different aspects such as density and stock and constructed an index using data infrastructure types.

Beihlh (1986) proposed infrastructure in the form of several categories namely energy supply, communication, transportation, water supply, health, education, environment, special urban amenities, sports and tourists facilities, social facilities, cultural facilities, and natural environment. Bruinsma *et al.* (1989) explained that the transportation infrastructural category is classified into subcategories such roads, railroads, waterways, airports, harbors, information transmission and pipeline. Nijkamp (1986) finds structures that differentiate infrastructure such as natural resource availability, locational condition, sectoral composition, international linkages and existing capital stock as the highest points of publicness, spatial immobility, indivisibility, non-substitutability and monovalence. Regional studies indicate the importance of infrastructure and institutional factors for trade facilitations. Abe and Wilson (2008) explained institutional facilitations indicators by using general equilibrium. Results show that regional trade would raise by 11% and global welfare expand by $406 billion due to reducing corruption and improvement in APEC economies. Iwanow and Kirkpatrick (2008) used data from Doing Business and World Bank Indicators of infrastructure and trade facilitation in border sense for 2003 and 2004. They applied a standard gravity model augmented with these factors and positive novelty in effectiveness on trade performance. Their study focused on African trade and interact indicators with an African dummy, finding that policies regarding improvement in these factors may yield a higher effect in African countries as compared to the rest of the world. Furthermore, Francois and Manchin (2007) applied a principal component to construct infrastructural and institutional quality indicators from different primary measures collected by several international organizations such as World Development Indicators and Fraser Institute. They find that indicators are robust determinants of trade. Hoekman and Nicita (2008) propose that non-tariff and tariff measures remain significant sources of trade restrictiveness in low income countries despite preferential access programs. They applied a gravity model by using indices of trade facilitations (infrastructure) and trade restrictiveness developed at the World Bank, in its Doing Business and Logistic Performance Index.

3. INFRASTRUCTURAL INDICATORS AND ECONOMETRIC ESTIMATION

This section describes constructing infrastructural indicators and econometric estimation strategies to incorporate the joint influence of hard and soft infrastructure on trade. First, in constructing the infrastructural indicators we applied the principal component and factors analysis techniques to interpret and refine the data. To reduce the multidimensionality of the data, the principal component analysis estimated the greatest variance in a new coordinate system. The first highest variance of the data lay in a new coordinate system or principal component with the remaining second greatest variance in a second coordinate or component and so on. Similarly, factor analysis is slightly more advanced method that has a similar interpretation of the principal component regarding the data. It proposes the unambiguous core model that estimates the correlation among a set of *m* observed variables through a linear combination of unobserved random factors. In this case of single factor F, the underlying model is defined[4] as

$$X_1 = \lambda_1 F + \varepsilon_1 \tag{1}$$
$$X_2 = \lambda_2 F + \varepsilon_2 \tag{2}$$

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[4] For more detail on factor analysis, see, for instance, Johnson and Wichern (2001) & Reyment and Joreskog (1993).

$$X_m = \lambda_m + \varepsilon_m \qquad (3)$$

Where λ_k is loading factors, X_k is observed factors. Loading factors are associated with observed factors. Both the estimations of factor loading and unobserved factors F per sub group variables retained synthetic indicator. These loading factors estimate the weights and correlation between each variable as well as common factor. The higher the load is the higher the relevance of the primary variable in defining the dimensionality of the data.

(a) Constructing the Infrastructural Indicators

For this purpose, we used fifteen primary variables collected from different organizations and sources such as the World Bank's World Development Indicators (WDI), the United Nations Economic and Social Commission for Asia Pacific Region (United Nations ESCAP), the World Bank Payment System, the CEPII, and the United Nations Conference on Trade and Development (UNCTAD).

Table-1. Loading Factors of Infrastructural Indicators.

Loading Factors of Transportation Infrastructural Indicators

Variable	Factor1	Uniqueness
denroads	0.5064	0.7436
denrailways	0.1142	0.9870
qualport	0.5085	0.7414
Cumulative variance: Variance = 0.52807, Proportion = 1.8381		

Loading Factors of Communication Infrastructural Indicators

Variable	Factor1	Uniqueness
mobilecs	0.5343	0.7146
sinternets	0.4282	0.8167
fixedts	0.5039	0.7461
fixedbs	0.1403	0.9803
Cumulative variance: Variance = 0.74232, Proportion = 1.6939		

Loading Factors of Border-transport efficiency Indicators

Variable	Factor1	Uniqueness
doctoexp	0.9070	0.1773
doctoimp	0.8743	0.2355
timetoimp	0.9166	0.1599
timetoexp	0.8904	0.2072
Cumulative variance: Variance = 3.22015, Proportion = 0.9409		

Loading Factors of Financial Infrastructural Indicators

Variable	Factor1	Uniqueness
deptransacc	0.8832	0.2199
posterminal	0.9622	0.0742
merchants	0.9745	0.0503
atmnetwork	0.1387	0.9808
Cumulative variance: Variance = 2.67477, Proportion = 1.0005		

Note: Our factor analysis procedure is based on two steps like aggregate infrastructure and main aggregate infrastructure. Each aggregate infrastructure contains four primary variables except of communication infrastructure. Main aggregate infrastructure is calculate based on hard and soft infrastructure. So, we used aggregate infrastructure to estimate the effect of indicators separately.
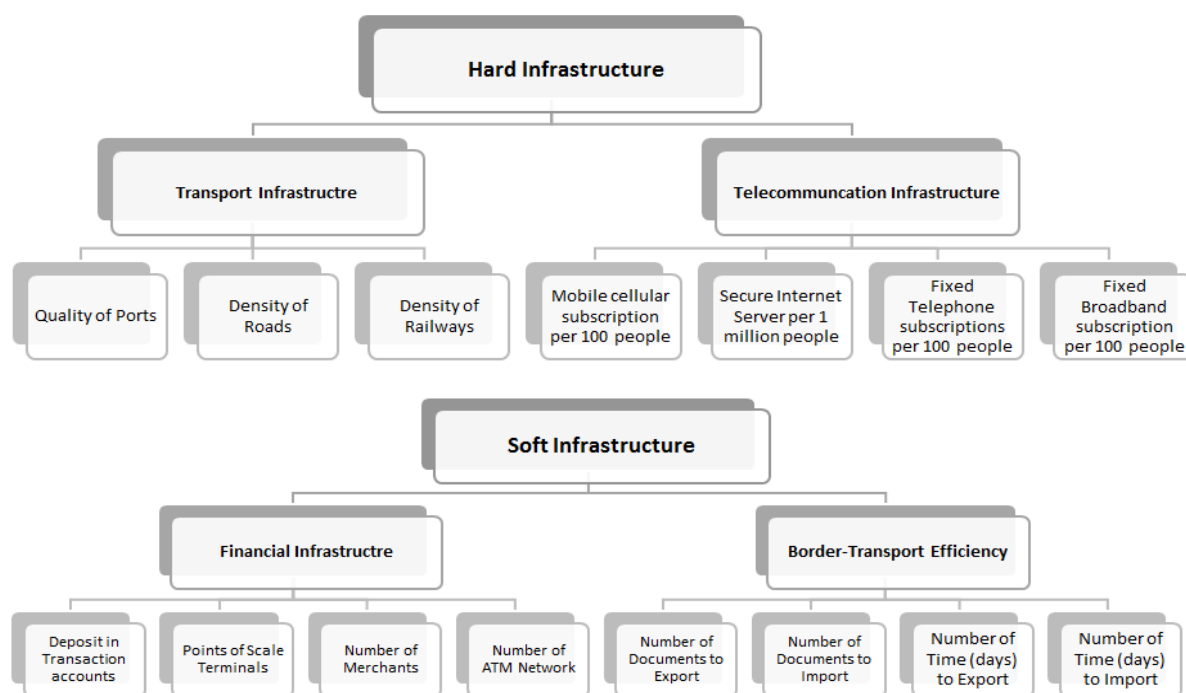
Figure-1. Aggregate and Single Indicators.

3.1. Hard Infrastructure

i. Transport infrastructure is defined as the physical services in the economy for moving goods from one place to another such as roads, railways, airports and ports. The density of roads is defined as the kilometer of roads per 1000 km square meter land area and the density of railway is defined as the kilometer of railways per 1000 km square meter land area. The quality of port infrastructure measures business executives' perception of their country's port facilities. Scores range from 1 (port infrastructure considered extremely underdeveloped) to 7 (port infrastructure considered efficient by international standards). Respondents in landlocked countries were asked how accessible port facilities were to them (1 = extremely inaccessible; 7 = extremely accessible).

ii. Telecommunication infrastructure is defined as the physical facilities that provide communication services in the economy such mobile phone subscriptions, broadband telephone lines, fixed telephone lines, internet user, servers for internet etc. Mobile cellular telephone subscriptions are subscriptions to a public mobile telephone service that provide access to the PSTN using cellular technology. The indicator applies to all mobile cellular subscriptions that offer voice communications. It excludes subscriptions via data cards or USB modems, subscriptions to public mobile data services, private trunked mobile radio, tele point, radio paging and telemetry services. Secure internet servers per 1 million people include servers using encryption technology in internet transactions. broadband subscriptions refers to fixed subscriptions to high-speed access to the public Internet (a TCP/IP connection), at downstream speeds equal to, or greater than, 256 kbit/s and fixed telephone subscriptions (per 100 people) refers to the sum of active number of analogue fixed telephone lines, voice-over-IP (VoIP) subscriptions, fixed wireless local loop (WLL) subscriptions, ISDN voice-channel equivalents and fixed public payphones.

3.2. Soft Infrastructure

i. Financial infrastructure is defined as the rules and regulations that enables the economy to run other systems such as banking systems and payment methods. Deposits in transaction accounts is defined as deposit accounts held with banks and other authorized deposit-taking financial institutions that can be used for storing value and making and receiving payments. Point of sale terminals are defined as the use of payment cards at a retail location (point of sale). The payment information is captured either by paper

vouchers or by electronic terminals, which in some cases are designed also to transmit the information. Merchants refer to merchants with POS terminals. A merchant can have multiple POS terminals and ATM networks which would involve at least two banks and/or other payment service providers.

ii.   Border-transport efficiency is defined as the level of efficiency of custom and domestic transport that is reflected in the time and number of documents necessary for export and import procedures. Doc to export is defined as the number of documents required to export during trade processes and doc to import is defined as the number of documents required to import during trade. TOEXPORT is defined as the amount of time (in days) to complete the export process and TOIMPORT is defined as the amount of time (in days) to complete the import process.

4. ECONOMETRIC ESTIMATION

To estimate the influence of several factors on the export volume, a more appropriate technique namely Gravity Model has been applied by different economists such as Tinbergen (1962) and Pöyhönen (1963); Anderson and Wincoop (2003), Bergstrand (1985; 1989); Helpman and Krugman (1985); Deardorff (1995). These authors applied the gravity equation to analyze international trade flows. It has become a popular instrument in analyzing foreign trade flows. There are some specific flows such as exports and imports from country i to country j and vice versa, geographical factors like physical distance, economic size GDP or GNP, population size, common language, common border, and common culture and language. Previous literature shows that there are large empirical studies done on gravity equations to improve the performance of the gravity equation. In recent papers, Mátyás (1997); Chen and Wall (1999); Breuss and Egger (1999) and Egger (2000) improved the econometric specification of the gravity equation. Bergstrand (1985); Wei (1996); Soloaga and Winters (1999); Limao and Venables (1999) and Bougheas *et al*. (1999) among others, contributed to the refinement of the explanatory variables considered in the analysis and to the addition of new variables.

In international trade, some important theories explain the theoretical foundation such as the Ricardian, Heckscher-Ohlin and increasing return to scale models. Estimation can derive from these theories. The theoretical foundation for estimating gravity equations were also enhanced by Anderson and Wincoop (2003; 2004). Work on firm heterogeneity by Helpman *et al*. (2008) found that a more productive firm finds it more profitable to export. Varying in destination does impact the profitability of export and higher demand improves higher exports that have fixed costs[5] .

We adapted the hard and soft infrastructure network hard and soft to estimate its joint influence on the volume of exports. We applied the FE, RE and Gravity Models to estimate the effect of infrastructure on exports. The augmented Gravity Model incorporates the relationship between variables and produced remoteness for checking the impact on dependent variables. We used the econometric techniques' two-stage sample selection model to correct several issues such as zero trade and heterogeneity, the two-stage model to focus on sample standard selection bias which is important in dropping observations with zero trade and bias due to the potential unobserved firm levels of heterogeneity[6]; and addressed the endogeneity problem by including a robustness check and adding

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[5]According to the model, firms distribution in country i to country j is assured with a marginal firms which break even during export, whereas positive profit may increase due to more productive firms during export. The model illustrates some appealing characteristics that may explain the trade flows appropriately. Firstly asymmetric trade flow can be generated between two countries by the model, secondly zero trade flow can be found between some country pairs, thirdly the model can estimate the generalized gravity equation which accounts for self-selection of firms into export markets and the impact on trade volume.

[6]We estimate the Probit regression that explains the probability of exports from country i to country j, whereas the dependent variable is the dummy variable that equal to 1 if exports are above average at a million US dollars between partners (bilateral) from country i to country j (selection equation) but is otherwise zero in first stage. The next stage consists of the gravity equation estimated in logarithm form which

more variables for estimating the impact. We also used the iterative reweighed least square and quartile regression for robustness that produced estimated weights for outliers. These techniques calculated the minimum sum of absolute of the residual rather than sum of square (OLS). So, we analyzed the estimation in two ways based on the mean and the median.

4.1. Estimation Model
We estimated the following specification as the outcome equation in terms of our sample model;

General Model

Trade = f (Hard infrastructure, Soft infrastructure, GDP, Population, Distance, Landlocked, Border, Tariff)

[7]Specific Model: (Affecting infrastructural factors on trade):

$$ln(exports_{ijt}) = \beta_0 + \beta_1\, ln(tran\text{-}inf_{it}) + \beta_2\, ln(com\text{-}inf_{it}) + \beta_3\, ln(fin\text{-}inf_{it}) + \beta_4\, ln(bor\text{-}tran\text{-}eff_{it}) + \delta_1\, ln(GDPpc_{it}) + \delta_2$$

$$ln(GDPpc_{jt}) + \delta_3\, ln(pop_{it}) + \delta_4\, ln(Pop_{jt}) + \delta_5\, ln(distance) + \delta_6\, Acc\text{-}ind\text{-}pac\text{-}sea_i + \delta_7\, Common\text{-}border_{ij} + \delta_8\, tariff_{ixt} + \delta_9$$

$$tariff_{imt} + \delta_{10}\, Inv\text{-}Mills_{ijt} + \varepsilon ijt$$

Where β (i = 1…4) coefficients, δ (i = 1…10) delta, *exports_{ijt}* are the exports from country i (export) to country j in year t; *tran-inf_{it}* is the transport infrastructure of country i in year t; *Com-inf_{it}* is the communication infrastructure of country i in year t; *fin-inf_{it}* is the financial infrastructure of country i in year t; and *Bor-tran-eff_{it}* is the border-transport efficiency of country i in year t. These are our four main aggregate infrastructural indicators. *GDPijt*, gross domestic product country i and j year t; *popijt*, population of country i and j year t; distance, physical distance in kilometer from capital to capital of trading country. *Acc-ind-pac-seat*, is dummy variable when a country has access to India or Pacific Ocean equal to 1 otherwise zero, *common-borderijt*, is also dummy variable when a country i has common border with country j, it is measured equal to 1 otherwise zero, *tariffijt*, imposed average tariff on exporting and importing country i and j year t. Inv-Mills_{ijt} is the inverse Mills ratio that corrects for selectivity in the Heckman selection model.

4.2. Data
The panel dataset covers 46 Asian[8] countries[9] over the period from 2001 to 2017. Data has been collected from several international organizations and sources such as the Payment system (World Bank), the United Nations Economic and Social Commission for Asia Pacific Region (UNESCAP), the CEPII, and the United Nations Conference on Trade and Development (UNCTAD). Bilateral trade (exports and imports) data was collected from

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explains the volume of exports from country i to country j (outcome equation). This estimation incorporates two terms: one is the inverse Mills ratio for the correction of nonrandom prevalence of zero trade issue while the second term takes into account the unobserved firm level of heterogeneity.

[7] This is a baseline model. We extended the model to examine the effect of the remoteness variable on exports.

[8] There are 46 countries from Asian regions excluding Asia Pacific under discussion except for North Korea and Palestine. Both countries don't share data on international organizations.

[9] Afghanistan, Armenia , Azerbaijan, Bahrain, Bangladesh, Bhutan, Brunei, Cambodia, China, Cyprus, Georgia, India, Indonesia, Iran, Iraq, Israel, Japan, Jordan, Kazakhstan, Kuwait, Kyrgyzstan, Laos, Lebanon, Malaysia, Maldives, Mongolia, Myanmar, Nepal, Oman, Pakistan, Philippine, Qatar, Russia, Saudi Arabia, Singapore, South Korea, Sri Lanka, Tajikistan, Thailand, Timor-Leste, Turkey, Turkmenistan, UAE, Uzbekistan, Vietnam, Yemen.

UNCTAD. We collected transportation infrastructural variable data namely density of roads and railways from UNESCAP and telecommunication infrastructural variable data from World Indicators Development (WDI). Similarly, the data of financial infrastructural variables were collected from the payment system (World Bank). The core gravity variables such as regional trade agreement, common border, landlocked and distance were collected from the CEPII. Other most relevant variables like GDP, population and tariff data were also collected from World Bank.

(a) Empirical Results and Discussions

We applied the two-stage Heckman selection model and the estimations are reported by Table 2 and defined by the expression (1) and (2). Outcome and selection equations are shown in columns 1a and 1b that report the estimated coefficients variables respectively. Standard errors are clustered by exporter-importer pair, following the HMR. Coefficients of all infrastructural indicators are not positive in outcome equation. The magnitude of infrastructure can be informative of the relative impact of this aspect of trade. The transportation infrastructural coefficient is the highest among all four coefficients. Border-transport efficiency appears to be the next significant indicator for exporters.

All other coefficients are significant and have expected signs. Larger distances, no access to the Indian or Pacific Oceans and higher tariffs between partners discourages trade volume, while common borders between partners causes trade cost reductions by land routes. The exporter's population might be affecting the trade through higher domestic demand in the country. Trade volume is higher between partners who have access to the Indian or Pacific Oceans and rich countries. Contiguous partner countries having a common border are likely to trade more intensively. The selection equation estimates provide the signal on influence of each determinant on the probability of exporting that is called extensive margin. Most coefficients are found significant and have same sign as in the outcome equations except for communication infrastructure which has a positive sign, although it is insignificant.

Next the estimates account for and correct the multilateral resistance following a procedure that is similar to Baier and Bergstrand (2009) and Behar *et al.* (2009)'s replacement of variables which vary across the exporter-importer pairs. [10] The coefficient of financial infrastructure remains negative and statistically significant. Transport infrastructure, communication infrastructure and border-transport efficiency were found positive and statistically significant.

All remaining infrastructural indicators have an impact on exports except for financial infrastructure. Transportation infrastructure and communication infrastructure play a significant role in the probability to export while border-transport efficient plays a less significant role. The coefficients of these variables are reported in column 2b and are both positive and statistically significant except for of border-transport efficiency.

We extended the estimation and reported on coefficients in column 3a and 3b that show the interaction term for each infrastructural indicator with respect to the gross domestic product. All interaction terms were found to be more significant than border-transport efficiency in outcome equations while all four indicators remain statistically significant but have different levels of significance in selection equations. Traditional gravity and trade policy variables remain with the expected same sign both in outcome and selection equations. The higher impact of transportation infrastructure and financial infrastructure seems to be important indicators in trade volume and probability to exports estimations.

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[10] Baier and Bergstrand (2009) introduces approximating price index multilateral resistance terms using a first order-Taylor expansion, yielding a long linear expression for MRT that is a function of exogenous variables. To estimate simple OLS, it can be included in estimation equation. MRT barriers can have larger impact on smaller countries that large proportion of trade internationally. MRT defined as: Remoteness $Rem_I = \sum i = dist\ ij$ / GDP_i/ GDP_w

We included two interaction terms between hard and soft infrastructure for testing the substitutability or complementarity characteristics of both types of infrastructure. Only hard infrastructure (transportationinf*communicationinf) is found to be positive and statistically significant, while soft infrastructure (financialinfr*border-transeff) remains more positive and insignificant in the selection equation rather than in the outcome equations. All coefficients of the infrastructural interaction terms remain positive and statistically significant except for soft infrastructure in the outcome equations for complementarity. [11]

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[11] During estimating the results by adding more combination of interaction term of hard and soft infrastructure, estimate does not change significantly.

Table-2. Substitutability or Complementarity of Infrastructural Indicators.

Variables	No GDP-Interaction, No MRT		MRT Correction		GDP Interaction		Infrastructure Interaction	
	1 (a)	1(b	2(a)	2(b)	3(a)	3(b)	4(a)	4(b)
	Outcome	Selection	Outcome	Selection	Outcome	Selection	Outcome	Selection
transportinf	0.0890**	0.00723	1.0850***	0.502***	10.99***	5.985***	-0.0787	-0.0691**
	(0.0356)	(0.0234)	(2.5760)	(0.104)	(0.921)	(0.540)	(0.0513)	(0.0304)
communicationinf	-0.0194	0.0296	3.3106***	0.143***	1.897***	1.812***	-0.142***	-0.0166
	(0.0430)	(0.0291)	(1.1936)	(0.0529)	(0.616)	(0.343)	(0.0496)	(0.0319)
financialinfr	-0.323***	-0.219***	-8.9966***	-0.527***	8.995***	5.895***	-0.347***	-0.207***
	(0.0402)	(0.0214)	(3.2566)	(0.130)	(0.700)	(0.372)	(0.0444)	(0.0248)
bordereff	0.0768***	0.0579***	573,829**	0.0196	1.495	1.277*	-0.0415	0.134*
	(0.0109)	(0.0101)	(254,275)	(0.0150)	(1.093)	(0.693)	(0.120)	(0.0770)
lngdpexporter	0.643***	0.396***	4.2596***	0.257***	0.642***	0.399***	0.687***	0.409***
	(0.0441)	(0.0159)	(1.1506)	(0.0463)	(0.0439)	(0.0176)	(0.0466)	(0.0164)
Transportinf*lngdpexporter					-0.419***	-0.231***		
					(0.0353)	(0.0208)		
Communicationinf*lngdpexporter					-0.0730***	-0.0685***		
					(0.0227)	(0.0128)		
Financialinfr*lngdpexporter					-0.360***	-0.238***		
					(0.0275)	(0.0146)		
Bordereff*lngdpexporter					-0.0484	-0.0418*		
					(0.0363)	(0.0231)		
Transportinf*communicationinf							0.188***	0.0951***
							(0.0404)	(0.0239)
Financialinfr*bordereff							-0.155	0.0979
							(0.156)	(0.100)
lndistance	-0.770***	-0.428***	-1.523***	-0.847***	-0.791***	-0.453***	-0.787***	-0.435***
	(0.0445)	(0.0195)	(722,890)	(0.0310)	(0.0440)	(0.0202)	(0.0455)	(0.0197)
Access to Sea	1.368***	0.800***	-2.830***	-1.870***	1.609***	0.962***	1.331***	0.796***
	(0.101)	(0.0419)	(8.817)	(0.334)	(0.114)	(0.0499)	(0.105)	(0.0428)
Common border	0.292***	0.441***	2.417	0.736***	0.285***	0.444***	0.283***	0.427***
	(0.0728)	(0.0453)	(1.497)	(0.0635)	(0.0718)	(0.0460)	(0.0735)	(0.0454)
lngdpimporter	0.738***	0.414***	3.402***	0.185***	0.758***	0.434***	0.746***	0.416***
	(0.0368)	(0.0103)	(1.074)	(0.0388)	(0.0370)	(0.0106)	(0.0375)	(0.0103)
lnpopexporter	-0.0809***	0.00622	-2.478	-0.0523	-0.168***	-0.0508***	-0.108***	-0.00340
	(0.0214)	(0.0144)	(3.478)	(0.139)	(0.0242)	(0.0158)	(0.0223)	(0.0147)
lnpopimporter	0.139***	0.120***	-1.193	-0.0505	0.128***	0.117***	0.137***	0.121***
	(0.0175)	(0.0108)	(806,850)	(0.0384)	(0.0172)	(0.0110)	(0.0178)	(0.0109)

xtariff	-0.0265***	-0.0193***	-580,797***	-0.0446***	-0.0294***	-0.0209***	-0.0272***	-0.0187***
	(0.0050)	(0.0028)	(180,824)	(0.00730)	(0.0052)	(0.0031)	(0.0050)	(0.00297)
mtariff	-0.0386***	-0.0211***	-488,834***	-0.0260***	-0.0396***	-0.0213***	-0.0397***	-0.0218***
	(0.0043)	(0.0027)	(135,444)	(0.00590)	(0.0042)	(0.0027)	(0.0043)	(0.00273)
Mills	1.508***		2.558***		1.480***		1.527***	
	(0.121)		(1.499)		(0.119)		(0.123)	
Constant	-18.85***	-21.15***	-6.671		-17.76***	-20.70***	-19.55***	-21.30***
	(1.920)	(0.367)	(6.385)		(1.904)	(0.433)	(1.983)	(0.370)
Observations	35,190	45540	35,190	45540	35,190	45540	35,190	45540

Note: Standard errors in parentheses. Significant level at *** 10%, **5% & *1%. Regressions are included two-stage Heckman (1979) & Multilateral Resistance (MRT) correction for (exporter & importer). Each variable is bilateral exception of access to Indian or Pacific Oceans. Common border is also included in bilateral term. Dependent variable are exports level and probability of export at above the average in US$, reported in outcome and selection equations respectively.

(b) Robustness Check

Hard and soft infrastructure could also be determined by several indicators such as trade and integration. So, a potential reverse causality problem may be existing. Certainly, higher investing in hard and soft infrastructure can provide higher returns to countries through exporting. Though causality is expected on both sides, better hard and soft infrastructure are more likely to have a direct influence on the probability and the volume of exports rather than the other way around.

Table-3. Robustness Checks.

Variables	Robustness	PPML	OLS
	1	2	3
	Outcome	Outcome	Outcome
transportinf	0.662***	0.683***	0.563***
	(0.0936)	(4.1505)	(0.0332)
communicationinf	1.274***	0.127***	0.816***
	(0.131)	(1.6505)	(0.0387)
financialinfr	-0.393***	-0.704***	-0.481***
	(0.0983)	(5.8605)	(0.0257)
bordereff	0.0787***	0.00523***	0.0870***
	(0.0263)	(2.5006)	(0.00963)
lngdpexporter	0.372***	0.249***	0.391***
	(0.0524)	(2.0805)	(0.0153)
lngdpimporter	-0.0429	0.174***	0.585***
	(0.0449)	(1.4905)	(0.0126)
lnpopexporter	0.676***	-0.0396***	0.626***
	(0.0664)	(5.9905)	(0.0153)
lnpopimporter	-0.289	-0.0599***	0.393***
	(0.198)	(9.0306)	(0.0135)
xtariff	-0.00389	-0.0251***	-0.00475
	(0.00714)	(3.2106)	(0.00301)
mtariff	0.0138	-0.0322***	-0.0191***
	(0.0125)	(2.3506)	(0.00314)
lndistance		-0.550***	-1.187***
		(7.2006)	(0.0267)
Access to Ocean	0.387*	-2.270***	0.483***
	(0.227)	(0.000192)	(0.0468)
Common border	3.371***	0.235***	1.649***
	(0.365)	(1.8605)	(0.0716)
Lntotaldistance	-0.836***		
	(0.186)		
Constant	3.475		-23.06***
	(4.202)		(0.350)
Observations	35,190	35,190	35,190
R-squared	0.499		0.563
Number of importer	46	46	

Note: Robust standard errors in parentheses, significant level at *** 10%, ** 5% & *1%. Regressions are included simple OLS, robustness check and Poisson-pseudo-maximum likelihood with control fixed effect. Log total distance is measure in kilometer from export country i to multiple destination country j. In this case, there are 46 countries

In this paper, the indicators' values do not greatly alter from year to year, especially for hard infrastructure and distance so any unexpected change in infrastructure did not occur due to trade flow. Additionally, applying the econometric technique factor analysis to construct the synthetic indicators attenuates the endogeneity problem.

However, we attempted to report the potential endogeneity[12] problem exploiting the lack of infrastructure on the new measurement of distance.

To deal with heteroscedasticity in constant elasticity models, we checked the consistency of the baseline estimates to OLS and pseudo-maximum-likelihood estimator (PPML) as suggested by Santos and Silvana (2006). They state that PPML produces estimates with the lowest bias for several patterns of heteroscedasticity. Column 1 (Table 3) reports this robustness check where we added one more variable based measurement scale. The coefficient of total distance remains negative and statistically significant, the same as column 3's simple OLS result.

The traditional gravity variable does not change its impact on exports between partners, although it is estimated in different measurement scales. All infrastructure indicators were found to be positive and statistically significant except for financial infrastructure. The higher impact of communication infrastructure seems very important between partners during exports. Exporting countries' characteristics, population and economic size remain positive and statistically significant, while importer countries' characteristics, population and economic size have a negative sign.

Column 2 (Table 3) reports the estimate of PPML where all infrastructural indicators have the expected positive sign and are more statistically significant than financial infrastructure. Countries' characteristics and those that have access to the Indian or Pacific Oceans remain negative but significant. The trade policy tariff variable also has the expected sign and significance. Only the transportation infrastructure coefficient shows a higher than expected impact on exports between partners.

Column 3 (Table 3) shows that with simple OLS estimates, by comparing with column 1 and 2 (Table 3), the coefficients of all infrastructural indicators have expected signs and are statistically significant. Most traditional and trade policy variables remain same as their expected signs with the PPLM and robustness checks[13]. The higher impact of communication infrastructure is the outlier in OLS column 3 (Table 3).

5. CONCLUSIONS

To analyze the relationship between exports and infrastructural indicators, we performed several econometric techniques including seventeen years of sample data on 46 Asian countries. We constructed infrastructural indicators on multiple sectors of the economy such as transportation, telecommunication, finance and trade facilitations by using principal component analysis and factor analysis econometric techniques that reduced the dimensionality of the data or found the correlation between variables.

In addition, the augmented gravity model including multilateral resistant terms with traditional gravity variables such as distance, common border, and access to sea or landlocked as well as a trade policy variable of the average tariff on all products imposed by the exporter and importer countries were also applied. For the robustness check, we applied iterative and quartile regression, and added more variables based on different measurement scales. We estimated the relationship between infrastructural indicators and bilateral exports in two dimensions. By constructing infrastructure indicators, we used fifteen primary variables from four sectors of the economy such as transportation infrastructure (density of the roads, density of the railway and quality of the port), telecommunication infrastructure (mobile subscriptions, internet server, fixed and broadband line), financial

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[12] We performed two stage least square regression (2SLS) for estimating the best strategy such as instrumental variables (IV) to test endogeneity, with total gross domestic product (GDP) including exporter and importer gross domestic product (GDP) as exogenous and instrumental variables respectively. Results exhibits that there are change in expected signs in aggregate variables as compared to simple OSL and 2SLS.

[13] To check robustness, we implied two more econometric techniques such as Iterative Reweight Least Square (IRLS) and Quantile Regression (QR) that is also estimate more robust against outliers in the response measurement. this technique gives less weight to outliers.

Note: all results available upon request.

infrastructure (deposit, ATM network, merchants, point of scale) and border-transport efficiency (documents to export, documents imports, time to export, time to import) for the period from 2001 to 2017 and collected data from different international organizations and sources.

We constructed two main aggregate variables like hard infrastructure and soft infrastructure as well as four indicators. First, we examined hard infrastructure and findings show that the transportation infrastructure variable remained positive in the relationship between bilateral exports by using the ordinary least square, fixed effect and random effect models, meaning that increasing the value of coefficient by 137% (reference Table 3 column 1) of transport infrastructure improved the bilateral exports. Simultaneous improvement in transportation infrastructure by increasing the density of the roads and railways, and the quality of the port may facilitate the exporter and importer to deliver the product to the desired destination faster and thereby reduce the transportation cost. Similar improvements in telecommunication infrastructure by increasing the values of coefficients lead to results of 154%, 259% and 282% (refer to Table 3 columns 1, 2 3). These improvements facilitate the exporter and importer during the movement of the product from origin to destination and keeps records regarding the trade activities. Soft infrastructure also allows the exporter and importer to reduce transaction costs and deliver the product in time to the destination.

The results provide evidence that improvements in financial infrastructure may improve the export volume by affecting both exporter and importer infrastructural indicators. We found that exporter and importer financial infrastructure remained positive in association with bilateral exports, meaning that improvement in the infrastructure of export countries may improve the export volume and similarly improvement in the infrastructure of importer countries may increase the level of exports. Another component of soft infrastructure, border-transport efficiency, improved the bilateral exports level by providing facilities to both the exporter and importer at the border locations. Improvements in border facilities increase the probability of the product delivery to the destination. Keeping records and preparing the documents for export and import, and decreasing the time to export and time to import at and across the borders may improve the efficiency of trade. This improvement in efficiency improves bilateral exports and helps with time sensitive products such as agricultural products. Findings show that border-transport efficiency remained positive in its association and was statistically significant at the 10% level for each econometric scale that was applied in this model.

The gravity model estimated the relationship with bilateral exports. Traditional gravity variables like distance, access to the oceans and common borders were found negative and positive with statistical significance at the 10% level for both. Each gravity variable is a bilateral unit rather than an aggregate or composite. The coefficients of distance were found at -.88 and -.94 with and without infrastructure, meaning that bilateral export is negatively affected by 88% and 94% due to one unit change in its coefficient with and without infrastructure.

The gravity model incorporated the multilateral resistant terms (MRT) such as distance, tariff, access to oceans and common borders with and without infrastructure to determine the effect on both exporter and importer countries' infrastructure. By comparing with and without the MRT, the impact of both exporter and importer countries' infrastructure indicators on bilateral exports is significant. Trade barriers reduce the amount of bilateral exports in different regions. We estimated the remoteness effect on the level of bilateral exports in the regions. The results illustrate that there is a negative impact of remoteness on bilateral exports but that it is significant at the 10% level. Findings suggest that efforts should be made in reducing the distance along with improvements in infrastructural quality and quantity especially in increasing the density of roads and railways as well as the quality of the ports. Improvement in transport infrastructure reduces transportation costs through reducing the distance.

Findings indicate that adding more variables such as distance but in different measurement scales does not change the relationship between the main infrastructural indicators and bilateral exports. We checked for the robustness by applying multiple methods: first adding more variables and second applying two econometric techniques namely IRLS and QR. However, there is no change in relationship but a little change in the value of

coefficients by applying OLS, IRLS and QR comparatively. To test the endogeneity in the model, we applied the best strategy of an instrumental variable by estimating a two stage least square (2SLS) model.

The results show that total gross domestic product (GDP) improves the level of bilateral exports with exporter and importer countries' infrastructure. The total GDP contains two components such as the GDP of the exporter and the GDP of the importer, taken as exogenous and endogenous variables in this model respectively.

This study suggests that improvements in each component of infrastructural quality and quantity like transportation, telecommunication, finance and border-transport efficiency must be increased to improve the trade facilities in the regions. This improvement requires higher investment in four sectors of the economy. Each Asian country's government should focus on the quality and quantity of hard and soft infrastructure simultaneously because infrastructure and borders affect each other. Better financial facilities for both the exporter and importer at and across borders increase the probability of trade occurring. A network of connecting infrastructure emphasizes the significant role of all the parts working together in hard and soft infrastructure such as transportation, telecommunication, and finance and border-transport efficiency. The findings of the paper suggest Asian nation-states should formulate policy to make improvements in infrastructure in each sector of the economy such as transportation, telecommunication, and finance and at and across border trade related activities.

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