The Economic Geography of Infrastructure in Asia: The Role of Institutions and Regional Integration

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Abstract: This study investigates the impact of spillover effects of the infrastructure on economic growth after controlling institutions and regional integration. Using a multidimensional infrastructure index that includes quantitative and qualitative dimensions, an empirical analysis is performed by estimating an augmented spatial endogenous growth model for a group of 35 Asian economies over the period 2006-2016. The results show that the infrastructure has a positive and significant effect, both direct and spillover, on regional development. Whilst, the quality of the infrastructure has a relatively greater direct impact, while quantity has a relatively higher spillover effect. This shows that the amount of infrastructure is more advantageous for the regions, whereas the quality is more fruitful for the country. Furthermore, analysis confirms the complementarity of the infrastructure with institutions and regional integration, which implies that these factors act as a stimulus to improve the spillover effects of the infrastructure. This analysis supports infrastructure development policies to achieve sustained economic growth in Asia. Infrastructure is a "big push" for these economies to uplift their economic status and eliminate poverty. The complementarity role of institutions and regional integration nictitates the consideration of these factors in planning infrastructure development policies, in particular economic corridors.

1. Introduction

Emerging economies have undergone spatial transformations through the development of infrastructure that allow the geographical distribution of economic activities to achieve competitiveness and collective prosperity. Infrastructure is one of tool which provides regional concentricity, generates economic activities and increases the productivity of other inputs, hence creates the necessary conditions to achieve regional development (Nijkamp, 1986). The collective regional prosperity is promoted through cross-region economic externalities. The infrastructure spillover effects are the main source of externalities (Ramajo, Marquez, Hewings, & Salinas, 2008).

The new economic geography (NEG) provides theoretical foundations for determining the spatial contributions of the infrastructure to economic growth (Fujita & Krugman, 2004). It hypothesis that the infrastructure reshapes the geographical connectivity and helps in the agglomeration of economic activities. Furthermore, it reduces trade costs and facilitates trade flows between countries, therefore it positively influences the product (Cohen, 2010). The benefits of infrastructure may not be limited to that specific region; therefore, it could have spillover effects in other regions (Chen & Haynes, 2015b).

The pioneering work of Aschauer (1989) has inspired a large body of empirical research with a regional focus. However, the literature is not conclusive about the contributions of the infrastructure. Few studies have established a positive relationship between infrastructure and economic growth (Easterly & Rebelo, 1993). While other studies have found a much smaller and in some cases negative link between infrastructure and growth (Devarajan, Swaroop, & Zou, 1996; Holtz-Eakin & Schwartz, 1995a). They suggest that, after controlling for region specific and unobserved characteristics, public capital may not be significant (Evans & Karras, 1994; Garcia-Mila, McGuire, & Porter, 1996). It is likely that the inconclusive contribution of infrastructure due to the fact that these studies overlook the existence of spillover effects (Boarnet, 1998; Elburz, Nijkamp, & Pels, 2017; Mikelbank & Jackson, 2000). Subsequently, literature shows that spillover effects of infrastructure should be an essential component of the empirical analysis of infrastructure impacts especially at regional level (Haughwout, 2002). The positive contributions of public investment in one area/region can be induced by infrastructures developed in other regions.

This leads to the concept of spillover effects that arise when public investment in one economy influences development in neighboring countries via trade and market integrations (C. Del Bo, Florio, & Manzi, 2010). Several attempts have been made to quantify the spillover effects of the infrastructure. These studies, however, provide inconsistent results regarding the direction and significance of spillover effects. Some studies have shown positive spillover effects of infrastructure on economic growth (Cohen, 2010; Dehghan Shabani & Safaie, 2018; Li, Wen, & Jiang, 2017; Pereira & Roca-Sagalés, 2003; Wang, Deng, & Wu, 2014). The positive economic spillover occurs due to a reduction in transaction and coordination costs, an increase in technological transfer and the promotion of industrial agglomeration (Berechman, 2002; Shanks & Barnes, 2008). Other studies have shown a negative spillover effects of infrastructure (Boarnet, 1998; Ozbay, Ozmen-Ertekin, & Berechman, 2007). The labor reallocation is termed a main source of negative spillover. Through agglomeration, the development of infrastructure in one region causes the labor force and manufacturers to migrate to other region, and therefore, generates a negative spillover effect (Boarnet, 1998). While some studies have shown either no or mixed spillover effects (Chen & Haynes, 2015b).

The differences in these studies derive from the role of underlying factors that channel the spillover effects and the lack of consensus on infrastructure measures. It argues that it is necessary to uncover mechanism by which various factors channel the contribution of the infrastructure (Esfahani & Ramírez, 2003). Other study also supports this by stating that "*under the right conditions, infrastructure development can play a major role in promoting growth and equity*" (Calderon, Cantu, & Chuhan-Pole, 2018). The literature, in this context, signify the role of institutions and regional integration as underlying factors in shaping the infrastructure contribution (Calderon et al., 2018; Chen & Haynes, 2015b; Esfahani & Ramírez, 2003; Iqbal & Nawaz, 2017a).

Institutions – "the rule of game" provide a favorable environment for channeling the impact of infrastructure on economic growth (Tanzi & Davoodi, 1998). Weak institutions reduce the marginal productivity of infrastructure investment by allowing rent seeking activities, especially in developing economies (Iqbal & Daly, 2014). Better governance seems to generate a greater impact of telecommunication infrastructure, electricity and sanitation on growth (Seethepalli, Bramati, & Veredas, 2008). While regional integration is a way to support the reallocation of resources and the development of regional production networks, which in turn support regional connectivity (Islam, Salim, & Bloch, 2016; Jouanjean, te Velde, Balchin, Calabrese, & Lemma, 2016). It provides an overarching cover to countries in the region to obtain benefits from infrastructure development. It allows free access to the regional markets, ensures the reduction of tariff and non-tariff barriers, promotes intra-regional trade and investment and, hence economic development (Iqbal & Nawaz, 2017a). Therefore, regional integration serves as a catalyst to enhance the spillover effects of infrastructure. The available literature does not explicitly consider the role of institutions and regional integration in measuring the spillover effects of infrastructure, so further research is needed.

Based on meta-analysis, a study reveals that the lack of consensus on infrastructure measurement is one reason for different results in the existing literature (Elburz et al., 2017). Two ways are used to define the physical infrastructure, namely the monetary value of the public investment (Devarajan et al., 1996) or the physical stock (Calderón, Moral-Benito, & Servén, 2015; Esfahani & Ramírez, 2003). However, physical measures are preferred due to the public nature of the infrastructure (Cantú, 2017; Keefer & Knack, 2007; Pritchett, 2000). For physical measures, literature uses a single infrastructure sector (Fernald, 1999) or has broad view of infrastructure, but its empirical estimate depends on the individual infrastructure sector, mainly telephone lines or road (Easterly, 2001). However, it is argued that physical infrastructure is a multidimensional phenomenon, so individual measure may not provide an adequate assessment of infrastructure. Addressing multidimensionality of the physical infrastructure by adding a series of infrastructure indicators as inputs also raises empirical problems, in particular over parameterization and multicollinearity (Calderón et al., 2015).

To capture multidimensionality, Calderón et al (2015) develop infrastructure index based on telecommunications, power and road transport using principal component method. The literature also stresses that the quality of infrastructure is as important as the quantity of infrastructure (Calderón & Chong, 2004; Cantú, 2017; Ismail & Mahyideen, 2015). However, the index develops by Calderón et al (2015) ignores the qualitative dimension of the infrastructure. Therefore, in order capture multidimensionality, a comprehensive index of the physical infrastructure is needed that includes quantity and quality dimensions.

This paper offers an assessment of economic spillover effects of infrastructure after controlling institutions and regional integration by using an augmented spatial endogenous growth model. A spatial panel estimation carried out for the Asian economies over the period 2006-2016 through the use of a multidimensional infrastructure index that includes quantity and quality dimensions. This study also examines the relative importance of quantity and quality dimensions to explain economic spillover effects of infrastructure for Asia. The case of Asia is very interesting for several reasons. First, the region has shown steady economic growth of more than 5.5% accompanied by a substantial reduction in poverty over last two decades[1]. Second, since 2009, the

[1] The poverty has declined from 61.6% in 1990 to 3.64% in 2013 in East Asia and Pacific region and from 44.41% to 15.4% in South Asia during the same time period (http://iresearch.worldbank.org/PovcalNet/data.aspx).

annul infrastructure investments has reached 8% of GDP, mainly financed by the public sector. Thirdly, regional integration has intensified since the 1990s in Asia, as evident from free trade agreements, foreign direct investment and financial integration[2]. Lastly, Asian economies lag behind in terms of institutional quality compared to developed regions[3]. These stylized facts provide a unique platform for studying the spillover effects of infrastructure in Asia.

The study contributes to the literature on various paths: First, it develops an augmented spatial endogenous growth model that incorporates the role institutions and regional integration in defining the spillover effects of infrastructure. Secondly, it builds a multidimensional infrastructure index using the Alkire and Foster method, which includes quantity and quality dimensions. The quantity dimension is captured using telecom, power, broadband and air, while quality dimension is based on electricity, port and road. This allows to capture multidimensionality of the infrastructure. Third, it addresses the possibility of endogeneity in infrastructure model. Finally, on the policy front, this study provides new insights on the importance of infrastructure development for regional economic development, especially in the context of spatial transformation. The results of the study help policy makers and politicians to create policies for greater integration and peace-building in the region.

Rest of paper is structured as follow: Section 2 provide a brief overview of existing literature; section 3 explains the development of an augmented spatial endogenous growth model; section 4 provides details on data and estimation methodology; section 5 presents the empirical findings and last section concludes the discussion with policy debate.

2. Literature review

Infrastructure has a direct and spillover effects on regional development. Direct effects are channeled to facilitate the production process, improve competitiveness, create jobs and increase factor productivity, leading to greater economic growth (Agénor & Moreno-Dodson, 2006; Sahoo & Dash, 2012). The spillover effects are explained using the new economic geography (NEG). Within an economy, industrial agglomeration, the expansion of the markets, the linkages between primary and secondary industrial units and product diversification are the fundamental sources of infrastructure spillover (Antonelli, 1993; Aschauer, 1989; Berechman, Ozmen, & Ozbay, 2006; Prud'Homme, 2005).

[2] https://aric.adb.org/datacenter

[3] According to the World Bank's World Governance Indicators (WGI), the East Asia and Pacific (EAP) ranked 56th percentile and South Asia at 34th percentile, compared to the OECD region which ranked 85th in control over corruption indicator. Where zero is the least desirable and 100 the most desirable rang. In regulatory quality, South Asia and EAP ranked in the 29th and 51st percentiles respectively, compared to OECD's 88th. The situation is similar for the rule of law, the government effectiveness, the voice and accountability and the political stability indicators. For further detail see http://info.worldbank.org/governance/WGI/#reports.

The cross-border spillover effects are explained in many ways. First, the infrastructure, especially the road, transport and communication, offers better connectivity across the regions. Secondly, the development of regional infrastructure induces new "*development competition*" among infrastructure producing and neighboring countries to take advantage of infrastructure development. This competition promotes regional competitiveness. Thirdly, the development of the infrastructure serves as a source of information about trading new markets operating in neighboring countries. This information spillover creates a demand effect in the local market for regional products. Fourth, better regional connectivity through the infrastructure reduces trade and transaction costs which ultimately promote the regional trade (Sahoo & Dash, 2012). Finally, communication infrastructure act as source of variety of innovations (Antonelli, 1993). The communication infrastructure for accessibility is vital to ensure high quality, reliable and low-cost communication and information facilities worldwide. The most common spillovers effect of communications infrastructure includes facilitating product innovation, technology diffusion, access to new consumers and low transaction costs. Access to information and knowledge through the advanced communication infrastructure allows the amalgamation of foreign and national markets, which in turn increases competition and market efficiency (Madden & Savage, 2000)

Several studies have been conducted to measure the spillover effects of infrastructure at country and regional level. The spatial econometric models are widely used to empirically disentangle the direct and spillover effects (Anselin, 2013; Elhorst, 2014; LeSage & Pace, 2010). However, due to the different focus of each study, there is no consistent conclusion on significance and direction of spillover effects of infrastructures. A number of studies have found a positive spillover effect of transportation infrastructure on economic performance in China (Hu & Liu, 2010; Li et al., 2017; Xueliang, 2008; Yu, De Jong, Storm, & Mi, 2013). Various studies have found a positive spillover effects of transport infrastructure on economic development for different states of the USA (Chen & Haynes, 2015a; Cohen, 2010; Ojede, Atems, & Yamarik, 2018; Tong, Yu, Cho, Jensen, & Ugarte, 2013). Similarly, few studies have found a positive spillover effects of infrastructure at the disaggregated level for Spain (Arbués, Banos, & Mayor, 2015; Cantos, Gumbau-Albert, & Maudos, 2005). Recently, various studies have found positive spillover effects of infrastructure in developing countries. For example, there is a positive spillover effect of infrastructure on economic growth in the Iranian regions (Dehghan Shabani & Safaie, 2018). The spillover effects of infrastructure are also investigated for the European Union (EU). A study confirms the positive role of infrastructure among EU countries. This study also identifies the highest rate of return associated with telecommunications and the accessibility of transportation network (C. F. Del Bo & Florio, 2012).

On the other hand, few studies have shown negative spillover effect of infrastructure (Boarnet, 1998; Cohen & Monaco, 2008; Moreno & López-Bazo, 2007; Ozbay et al., 2007; Sloboda & Yao, 2008). The negative spillover effects are explained using labor migration effect through industrial agglomeration. Through agglomeration, the development of a region's infrastructure makes manpower and producers migrate to the region, which in turn reduces growth in other regions. The evidence on negative spillovers effects signifies the likelihood that infrastructure investment produces only small production gains in a region or state (Boarnet, 1998; Moreno & López-Bazo, 2007). While some studies have shown no or mixed spillover effects of infrastructure on development (Chen & Haynes, 2015a; Holtz-Eakin & Schwartz, 1995b; Jiwattanakulpaisarn, Noland, & Graham, 2011; Kelejian & Robinson, 1997; Sahoo & Dash, 2012; Xueliang, 2008; Yu et al., 2013). The differences in outcomes are contributed to the use of infrastructure measure, time period, areas specification, underlying model and estimation methodology (Elburz et al., 2017)[4].

Apart from differences in outcome due to methodological differences, these studies do not consider the role of underlying factors in explaining spillover effects. The literature signifies the role of contextual factors, including institutions and regional integration to channel the impact of infrastructure on economic growth (Esfahani & Ramírez, 2003; Gupta, Clements, Baldacci, & Mulas-Granados, 2005; Haque & Kneller, 2015; Tanzi & Davoodi, 1998). These studies argue that institutions play an important role in improving infrastructure-growth nexus. The institutions frame public policy to ensure right allocation of public resources. Institutions improve productivity of public investment by diverting them to the productive sector (Cavallo & Daude, 2011; Gupta, De Mello, & Sharan, 2001; Mauro, 1998; Nawaz & Khawaja, 2018). While, the economic integration is helpful in promoting efficiency in the use public resources on a regional basis, hence enhancing economic growth (Holod & Reed III, 2004; Robson, 1998). Opening an economy to investment and trade would automatically improve economic development (Krueger, 1997).

This discussion reveals that institutions and regional integration play fundamental role in channeling spillover effect of infrastructure at wider canvas. The available literature does not include these factors to explain economic spillover effects of infrastructure. This could be linked with the scope of existing studies. With very few exceptions, mostly studies are conducted at sub-national level like regions in China (Hu & Liu, 2010; Li et al., 2017; Xueliang, 2008; Yu et al., 2013), States/Counties in USA (Chen & Haynes, 2015a; Cohen, 2010; Ojede et al., 2018; Tong et al., 2013) and states in Spain (Arbués et al., 2015; Cantos et al., 2005). The implicit assumption of these studies could be the similar institutional framework and free trade across all

[4] A summary table of these studies to show differences in use of infrastructure indicators, area, time period, theoretical model and estimation technique is given in *Appendix Table 1*.

states/regions/counties. However, this may not be true when a group of countries with different development status is considered for analysis, hence a detailed study is needed to look at the role of institutions and regional integration. This study is step toward this direction.

3. Modelling Framework

This study develops an augmented spatial endogenous growth model to illustrate the complementarity of the infrastructure with the institutions and the regional integration in defining the spillover effects of infrastructure. We start with a Cobb Douglas type production function defined by Aschauer (1989) and Barro (1990). It incorporates the public spending as an additional input in production function[5] as given below.

$$Y_{it} = K_{it}^{\alpha} P_{it}^{\beta} H_{it}^{\gamma} (AL_{it})^{1-\alpha-\beta-\gamma} \quad \ldots (1)$$

where Y is real output of a country i at given time t. K, P and H represent physical capital, physical infrastructure and human capital, respectively. L donates the labor force while A measures the total factor productivity. $\alpha \in (0,1)$, $\beta \in (0,1)$ and $\gamma \in (0,1)$ represent the share of K, P and H, respectively, while $1 - \alpha - \beta - \gamma$ is the share of L with $\alpha + \beta + \gamma = 1$ i.e. constant return to scale assumption. In per capita, it can be written as[6]:

$$y = Ak^{\alpha} p^{\beta} h^{\gamma} \quad \ldots (2)$$

where y is real output per worker, k, p and h indicates stocks of physical capital, infrastructure and human capital in per worker term, respectively.

The basic production function extends in two ways. First, as discussed above, weak institutions allow diversion of public resources to unproductive sectors due to weak accountability. This is the main source of rent seeking activities (RSA) that reduces economic output (Gradstein, 2007; Iqbal & Daly, 2014). While strong institutions reduce RSA, therefore, factors productivity and economic growth increases. Based on these arguments, we extend the production function to incorporate the distortions created by RSA (Nawaz, Iqbal, & Khan, 2014). The extended production function takes the following form:

$$y = (1 - r)Ak^{\alpha} p^{\beta} h^{\gamma} \quad \ldots (3)$$

where r indicate RSA where $r \in [0, \hat{r}]$ and $\hat{r} \ll 1$. The share of RSA by each firm depends on institutional quality implying that higher the quality of institutions, lower the value of r (Nawaz et

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[5] The stock of public capital may enter the production function directly, as a third input or indirectly through multifactor productivity (Romp & De Haan, 2007). However, it does not make any difference whether public capital is treated as a third input or as influencing output through factor productivity in a Cobb Douglas function as both ways of modelling yield similar estimation equation (Sturm, Kuper, & De Haan, 1998).

[6] For simplicity, we omit time and country subscript.

al., 2014). The higher the marginal benefits of r implies weak institutions, and therefore low factor productivity and vice versa. Therefore, r lowers the marginal productivity of input factors owing to weak institutions. This extension gives meaningful description to the cross-country differences in economic growth rates.

Second, this study extends the basic model by augmenting the role of regional integration through total factor productivity A. A is sole determinant behind economic growth in standard neoclassical theory. It advances at rate of g given by $A = A_0 e^g$, where g is constant growth rate of technology. However, the literature suggests that regional integration improves overall productivity by ensuring technological spillover, allowing better quality inputs, increasing competitiveness and market discipline, increasing foreign investment and providing opportunities for access to the free market in the region (Islam et al., 2016). It creates a favorable business environment by the reducing risk premium for investment and reducing the cost of raising capital from a larger market (Badinger, 2005). To model the role of regional integration, this study assumes that A is determined by g and regional integration I. Therefore, A is defined as:

$$A = A_0 e^{gt+\vartheta I} \dots \dots \dots \dots (4)$$

where ϑ measures the outcome of regional integration. This allows to quantify the impact of regional integration which tend to increase the productivity of inputs[7]. The extended production function per worker form is as:

$$y = (1-r)\left(A_0 e^{gt+\vartheta I}\right) k^\alpha p^\beta h^\gamma \dots \dots \dots \dots (5)$$

To determine the long run growth path, we suppose government expenditures are funded by income tax at a rate τ with balance budget i.e. $g = \tau y$. Further, we assume a representative agent who maximizes utility subject to given budget constraint with following preferences: $U = \int_0^\infty \frac{c^{1-\sigma}-1}{1-\sigma} e^{-\rho t} dt$. Where c is private consumption per capital with $\sigma > 0$ and $\sigma \neq 1$ and $e^{-\rho t}$ measures time preference with $\rho > 0$. The dynamic budget constraint is as follow:

$$\dot{k} = \frac{dk}{dt} = (1-\tau)(1-r)Ak^\alpha p^\beta h^\gamma - c \dots \dots \dots \dots (6)$$

Further, we suppose $k_{(0)} = 1$ with $\lim_{t\to\infty} k\lambda e^{-\rho t} = 0$ representing initial stock of capital at time period 0. The agent chooses consumption and investment paths given the $\{c_{it} : t \geq 0\}$ $\{c_t : t \geq 0\}$ and $\{k_{it} : t \geq 0\}\{k_t : t \geq 0\}$. To find solution, Hamiltonian is defined as:

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[7] Various studies have used similar fashion to model A to capture the impact of government policies, institutions and financial development (Demetriades & Hook Law, 2006; Nawaz & Khawaja, 2018).

$$H = \frac{c^{1-\sigma} - 1}{1-\sigma} e^{-\rho t} + \lambda\left[(1-\tau)(1-r)Ak^{\alpha}p^{\beta}h^{\gamma} - c\right] \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots. (7)$$

where λ is shadow price of income. After applying first order conditions and imposing $\lim_{t\to\infty} k\lambda e^{-\rho t} = 0$, we find per capita consumption growth rate which is equal to the growth rate of output: The output growth rate is given as:

$$\frac{\dot{y}}{y} = \Phi(1-r)e^{gt+\vartheta I}k^{\alpha-1}p^{\beta}h^{\gamma} - 1 \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots. \dots\dots (8)$$

where $\left[\frac{(1-\tau)}{\rho}\right] A_0\alpha = \Phi$. The equation (8) provides basis to study infrastructure-economic growth nexus after controlling institutions and regional integration. The model can be written as follow after applying log transformation:

$$ln y^{*} = ln\left(\frac{\dot{y}}{y}\right) = ln\Phi + \ln(1-r) + gt + \vartheta I + (\alpha-1)lnk + \beta\ln p + \gamma ln\text{h} \dots\dots\dots\dots\dots\dots. (9)$$

We transform equation (9) into a compact version of regression equation as given below:

$$lny_{it} = lnx_{it}\beta + \mu_i + \varepsilon_{it} \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots. \dots\dots.. (10)$$

where lny_{it} is independent variable of log GDP per capital for country i at time t. i is an index for the countries (spatial units), with $i = 1 \dots\dots, N$, and t is time dimension (year), with $t = 1 \dots\dots, T$. β represents coefficients attached with matrix x which represents explanatory variables and their interactions. μ_i is the individual fixed effects, which allows to control area/country specific factors those are time- invariant and ε_{it} is error term with a zero mean and variance.

To analyze the spillover effects of infrastructure, this model is further expanded to adjust the spillover effects. The spatial modelling strategy is used to model spillover effects (LeSage & Pace, 2010)[8]. The spatially integrated regression model is given below:

$$lny_{it} = \varrho\sum_{j=1}^{N} w_{ij}lny_{jt} + lnx_{it}\beta + \sum_{j=1}^{N} w_{ij}lnx_{jt}\,\varphi + \mu_i + \varepsilon_{it} \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots.. (11)$$

where $\sum_{j=1}^{N} w_{ij}lny_{jt}$ is the spatially weighted effects of lny_{it}. This helps to measure the spillover effects of dependent variable. In this case, it implies that GDP per capita in country i is shaped by GDP per capita of neighboring countries j as a consequence of spillover effects. With lny_{jt} in neighboring countries; the parameter ϱ is the coefficient attached the autoregressive term. It measures the power of spatial correlation between two countries. In this model, this parameter

[8] This strategy is widely used in the exiting literature (Arbués et al., 2015; Cohen, 2010; Li et al., 2017; Ojede et al., 2018).

gives the impact of GDP per capita of neighboring countries. w_{ij} is spatial weight matrix that captures the spatial interaction among countries. φ is a vector of coefficients linked with explanatory variables other than the lag of dependent variable. These adjustments in the original model provide basis to disentangle the direct and spillover effects of infrastructures on economic growth after controlling underlying factors.

4. Data and methodology

4.1. Data

This study is based on panel data of 35 countries from Asia over the period 2006-2016[9]. The core reason of limiting data to 35 Asian countries is the existence of quality data on important variables of interest, especially infrastructure. The data on GDP, gross fixed capital formation, labor force, openness, urbanization, fixed telephone subscriptions and electric power consumption are taken from the World Development Indicators (WDI). The data on institutional variables are retrieved from the World Governance Indicators (WGI). These two datasets are published by the World Bank. The data on education and health indices are obtained from the Human Development Data published by the United Nations Development Programme (UNDP)[10]. The data on quality indicators of infrastructure are obtained from the Quality of Government (QoG) Institute (Teorell et al., 2018). The information on regional trade agreements is obtained from Regional Trade Agreements Information System maintained by the World Trade Organization (WTO)[11].

4.1.1. Physical Infrastructure index (INF)

To capture the multidimensionality of physical infrastructure, this study develops a comprehensive index of physical infrastructure. Deriving from literature, physical infrastructure (INF) has two broad dimensions, namely quantity of INF (IQT) – captures the physical availability of infrastructure like road density or no of telephone line and quality of INF (IQL) – capture the quality of available physical infrastructure like ratio of paved road and uninterrupted power supply. Following the literature (Calderón & Chong, 2004; Calderón et al., 2015; Calderón & Servén, 2014) and based on availability of data, four indicators are used to measure quantity of INF including: i) telecommunication (IQT1); ii) power (IQT2); iii) broadband (IQT3); and iv) air transport (IQT4)[12]. To measure the quality of INF, three indicators are derived from literature (Ismail & Mahyideen, 2015); namely: i) electricity (IQL1); ii) port (IQL2); and iii) road (IQL3).

[9] ***Appendix Table 2*** provides the list of sample countries.
[10] http://hdr.undp.org/en/data
[11] For further information, see http://rtais.wto.org/UI/PublicMaintainRTAHome.aspx
[12] Definition of each indicator is reported in ***Appendix Table 3***. Road density is another important indicator to measure the quantity of infrastructure. However, the data on Road length is nor freely available, which restrict us to ignore this variable.

We use Alkire and Foster methodology to develop multidimensional infrastructure index (Alkire & Foster, 2011), subsequently used by many studies (Alkire, Roche, & Vaz, 2017; Iqbal & Nawaz, 2017b). After selecting indicators, the next step is to define the weight of each indicator. All indictors used in the construction of index are not in the same unit and more importantly these have different ranges. In first step, each indicator is normalized with common range from 0 to 1. Both dimensions are equally weighted, so each dimension receive a 1/2 weight. The indicators within each dimension are equally weighted[13]. Following formula is used to construct final index:

$$INF = 0.5\left[\frac{1}{8}(\mathrm{IQT1} + \mathrm{IQT2} + \mathrm{IQT3} + \mathrm{IQT4})\right] + 0.5\left[\frac{1}{6}(\mathrm{IQL1} + \mathrm{IQL2} + \mathrm{IQL3})\right]$$

This provides a multidimensional infrastructure index.

4.1.2. Institutional quality index (INS)

The institutional quality index (INS) is developed using the World Governance Indicators (WGI) dataset. This data provides six different dimensions to capture institutional quality[14]. These include: 1) "Control of corruption" (CC); 2) "Government effectiveness" (GE); 3) "Political stability and absence of violence/terrorism" (PA); 4) "Regulatory quality" (RQ); 5) "Rule of law" (RL) and 6) "Voice and accountability" (VA). Each dimension falls within the range of -2.5 and +2.5. Where lower value means weak institutions and vice versa. To construct institutional quality index, same procedure is applied as in case of infrastructure index. Normalized series are used in construction of final index as given:

$$INS = \frac{1}{6}(\mathrm{CC} + \mathrm{GE} + \mathrm{PA} + \mathrm{RQ} + \mathrm{RL} + \mathrm{VA})$$

4.1.3. Regional Integration index

To measure the impact on regional integration, this study uses two proxies. Following the standard literature, first we use trade openness as measure of regional integration (Fetahi-Vehapi, Sadiku, & Petkovski, 2015; Freund & Bolaky, 2008; Fujita, Krugman, & Venables, 2001; Keho, 2017; Tumwebaze & Ijjo, 2015). Trade openness (OPN) is given as percentage of total trade with respect of GDP (imports plus exports as % of GDP). Secondly, regional trade agreements (RTA) are also used to quantify the impact on regional integration on growth (Iqbal & Nawaz, 2017a). A normalized population adjusted RTA index is constructed using number of RTA signed by each

[13] UNDP has also used similar method to construct human development index. For further details see http://hdr.undp.org/sites/default/files/hdr2016_technical_notes_0_0.pdf. Principal component method is also used to find the weight of each indicators. Principal component method is also used to develop infrastructure index; however, this method also gives similar weights for all variables (Calderón et al., 2015).

[14] Various studies have used this data to examine the role of institutional quality in explaining economic growth (Nawaz et al., 2014).

country. Liu (2016) also uses WTO signed RTA to measure the impact of regional integration on economic growth.

4.1.4. Other variables

The human capital index (HC) is created using two dimensions available in Human Development Index (HDI), namely education dimension and health dimension. The education dimension is evaluated by mean of years of schooling while health dimension by life expectancy at birth. Iqbal and Daly (2014) find that health is as important as education to quantify the impact of human capital on development. Both dimensions are equally weighted, hence the final HC is defined as follows:

$$HC = 0.5(EDU) + 0.5(HEALTH)$$

The grossed fixed capital formation per worker is used to quantify the impact of physical capital (PC) on economic development. Various studies have used this measure in growth analysis (Ahmad & Hall, 2017; Iqbal, Din, & Ghani, 2012). Urbanization is also an explanatory variable to capture the role of rising urbanization especially in Asian economies. Share of urban population in total population is used as proxy of urbanization. The economic development is measured using GDP per worker at constant prices (US$ 2010). The descriptive statistics of all variables are reported in Table 1.

Table 1: Summary Statistics

Variables	Mean	Std. dev	Max	Min	Skewness	Kurtosis	Correlation
Ln(GDP)	9.353	1.311	11.527	6.913	0.018	1.866	1.000
Ln(INF)	3.422	0.581	4.358	1.488	-0.429	2.526	0.869*
Ln(PC)	12.553	1.371	15.313	9.083	-0.114	2.061	0.981*
Ln(HC)	4.282	0.131	4.519	3.928	-0.605	3.204	0.754*
Ln(URN)	3.975	0.506	4.605	2.741	-0.647	2.386	0.891*
Ln(OPN)	8.902	1.553	12.501	5.528	0.183	2.261	0.932*
Ln(INS)	3.705	0.392	4.480	2.075	-0.641	4.805	0.713*
Ln(RTA)	1.345	1.610	4.605	-2.521	-0.079	2.276	0.406*

Source: Author's own calculation. Last column presents the correlation matrix with Ln(GDP). * indicates significant correlation at 5% level.

4.2.Estimation methodology: Spatial econometric approach

The spatial econometric technique is used to estimate model given in equation (10). The choice is motivated by econometric problems emerge due to existence of spatial correlations among variables (Maddison, 2006). While omitting the spatial correlations when variables are spatially correlated produce biases estimates (Anselin, 2013). Recent literature on spillover effects of infrastructure mainly relies on this approach to produce robust results (Arbués et al., 2015; Cohen, 2010; Ojede et al., 2018). According to literature, spatial panel econometric models are divided into three kinds (Elhorst, 2014): i) "Spatial Lag Panel Model" (SLPM); ii) "Spatial Error Panel Model" (SEPM), and iii) "Spatial Durbin Panel Model" (SDPM). In SLPM model formulation, a lag of spatially weighted dependent variables is used an independent variable. This model assumes that values of dependent variables observed at one country/location is partially effected by the values of nearby dependent variables those are spatially weighted using weighted matrix. In contrast to spatially lagged specification, SEPM employs a spatially auto-correlated error term. This model assumes that omitted variables cause regional interaction effects. While SDPM is an expanded version that include both spatially weighted lag dependent and explanatory variables. A comprehensive SDPM can be developed by integrating SLPM and SEPM (LeSage & Pace, 2010). Using model given in equation 11, this study defines following SDPM model:

$$\begin{aligned} lny_{it} = \varrho \sum_{j=1}^{N} w_{ij} lny_{jt} + \beta_0 + \beta_1 lnPC_{it} + \beta_2 lnINF_{it} + \beta_3 lnHC_{it} + \beta_4 lnOPN_{it} + \beta_5 lnURN_{it} \\ + \beta_6 lnINS_{it} + \beta_7 lnRTA_{it} + \varphi_1 \sum_{j=1}^{N} w_{ij} lnPC_{jt} + \varphi_2 \sum_{j=1}^{N} w_{ij} lnINF_{jt} + \varphi_3 \sum_{j=1}^{N} w_{ij} lnHC_{jt} \\ + \varphi_4 \sum_{j=1}^{N} w_{ij} lnOPN_{jt} + \varphi_5 \sum_{j=1}^{N} w_{ij} lnURN_{jt} + \varphi_6 \sum_{j=1}^{N} w_{ij} lnINS_{jt} + \varphi_7 \sum_{j=1}^{N} w_{ij} lnRTA_{jt} \\ + \mu_i + \varepsilon_{it} .. (12) \end{aligned}$$

The proposed SDPM given in equation (12) includes three kinds of spatial interactions, namely, endogenous, exogenous and correlated interaction effects. However, estimates become biased when all three kinds of spatial effects are included simultaneously in estimation model (Elhorst, 2014). To resolve this, it is proposed to exclude the spatially weighted error term (LeSage & Pace, 2010).

Various diagnostics tests are used to establish the existence of spatial autocorrelation and cross-sectional dependency. First, the Moran's I test is used to examine the existence of spatial auto correlation. For this, pooled ordinary least square (OLS) based model is estimated. Rejecting the null hypothesis implies the existence of spatial autocorrelation, hence traditional estimators may produce inconsistent results. To examine the cross-sectional dependency, we apply cross-sectional dependence (CD) test (Pesaran, 2015). The test examines whether variables or errors are correlated between group in a panel. Rejecting the null hypothesis confirms the existence of cross sectional dependency.

To find the optimal model among three spatial econometric estimators, best suited to data, this study uses Lagrange Multiplier (LM) lag (robust) and LM error (robust) tests (Anselin, 2013)[15]. These tests are used to examine; i) whether the SDPM can be simplified to the SLPM:

[15] The Wald and LR tests can also be used to find the optimal models. For further detail on advantages on LM (robust)

$H_0: \varphi = 0$ and ii) whether the SDPM can be simplified to the SEPM: $H_0: \varphi + \varrho\beta = 0$. Rejection of both null hypothesis favor SDPM as an optimal formulation.

To estimate optimal spatial model, the OLS may not be the appropriate approach. It tends to produce biased or inefficient results owing to the inclusion of spatial weighted matrix (You & Lv, 2018). Three methods are frequently considered in literature to estimate spatial model; include i) "Maximum Likelihood" (ML) estimator and the "Quasi Maximum Likelihood Method" (QML); ii) the "Instrumental Variable" (IV) or "Generalized Moment Method" (GMM), and iii) the "Markov Chain Monte Carlo Method" (MCMC) (Elhorst, 2014). Based on literature, this study uses Maximum Likelihood (ML) estimators (Arbués et al., 2015; You & Lv, 2018).

The construction of w_{ij} is very important in spatial econometric model as different specifications capture different channel of spillovers (LeSage & Pace, 2010). Following literature, this study uses physical contiguity matrix. In this matrix, a value 1 is assigned for two countries having common border while 0 for all others (Arbués et al., 2015). Apart from this, this study also uses inverse of distance between countries matrix to model distance factor.

Up to now, we consider infrastructure exogenous to the economic system. However, this may not be the case as literature has pointed the endogenous nature of infrastructure due to reverse causality (Arbués et al., 2015). The issue in compounded when infrastructure variable is added in equation that has other variables like institutions, trade and human capital (Nawaz & Khawaja, 2018). The use of ML resolved the issues associated with the endogeneity arises due to the inclusion of spatially weighted lag of the dependent variable. Furthermore, the use of spatial fixed effects technique addresses the omitted variables bias. However, these estimators may not address endogeneity among the explanatory variables.

To address endogeneity and establishes the robustness of results, this study uses system GMM (Arellano & Bover, 1995; Blundell & Bond, 1998; Bond, Bowsher, & Windmeijer, 2001). The system GMM is based on system where two equations are considered; one in difference form while other in level form. The difference form equation is instrumented by the lag levels whereas the level form equation is instrumented by lag difference. The lag values of variable are less likely to be effected by recent economic shocks, so they are not correlated with the error terms (Iqbal & Daly, 2014).

see https://spatial.uchicago.edu/sites/spacial-data.uchicago.edu/files/9_specification_tests_1_slides.pdf and https://spatial.uchicago.edu/sites/spacial-data.uchicago.edu/files/10_specification_tests_2_slides.pdf. You and Lv (2018) also used LM (robust) tests to find the optimal model for spatial analysis against non-spatial panel models.

5. Empirical results and discussion

This section presents the empirical analysis and discussion. To ascertain the adequacy of spatial econometric model, various diagnostic tests are used. The Moran's I test validates the occurrence of spatial autocorrelation. The Moran's I has a positive and significant value which implies that economic development in the Asian economies has a positive spatial autocorrelation. The spatial dependence across the countries among all variables is also confirmed by the Cross-sectional Dependence (CD) test (Table 2). It suggests that the estimation without controlling for spatial dependency may produce biased estimators.

We perform LM lag (robust) and LM error (robust) tests to find the optimal spatial model among three spatial econometric estimators. To apply these tests, an OLS based models are estimated. The null hypothesis is strongly rejected (at the 1% significance level) as value of LM lag (robust) is 88.9 (37.4). This shows that lag dependent variable is spatially correlated. Similarly, the value of LM error (robust) is 81.5 (30.0) also confirm the existence of spatial autocorrelation in error term. Both tests are statistically significant at 1% levels (Table 2). This implies the best model is SDPM as the null hypothesis of SLPM and SEPM are strongly rejected by LM (robust) tests. Based on these diagnostic tests i.e. Moran's I, LM (robust) and CD, it can be concluded that SDPM is an optimal model to produce reliable estimates.

Table 2: Moran's I, LM and CD Tests

Test	Statistics (P-Values)	Variables	CD-test
Moran's I	3.774 (0.00)	Ln(GDP)	24.05***
Spatial Error Model		Ln(INF)	18.07***
LM tests	81.480 (0.00)	Ln(PC)	9.60***
Robust LM	30.024 (0.00)	Ln(HC)	77.00***
Spatial Lag Model		Ln(OPN)	46.91***
LM tests	88.889 (0.00)	Ln(INS)	12.04***
Robust LM	37.433 (0.00)	Ln(RTA)	14.99***

Source: Author's own calculation. Column 1& 2 presents the Moran's I and LM (robust) tests. P-values are given in parenthesis. While column 3 & 4 give CD test for each variable. The CD test is performed using "xtcd" STATA 15 command. Test is performed under the null hypothesis of cross-section independence CD ~ N(0,1). *** indicates significant at the 1% level.

The results of non-spatial regression panel models are presented in Table 3. Four different specifications are estimated. The estimation results of non-spatial panel models show that infrastructure has a positive and significant impact on economic development measured through GDP per capita – labor adjusted. The estimated coefficients which represent the elasticities range from 0.176 to 0.216 and statistically significant at the 1% level1. This implies that increases in infrastructure would lead to an increase in GDP per capital from 1.76% to 2.16%. The positive contribution infrastructure is supported by many studies (Aschauer, 1989; Babatunde, 2018; Calderón et al., 2015; Égert, Kozluk, & Sutherland, 2009).

Table 3: Estimation results of non-spatial panel models

	Without fixed effects	With fixed effects		
Variables	Pool OLS	Spatial fixed effects	Time period fixed effects	Spatial & time period fixed effects
Ln(INF)	0.216***	0.176***	0.221***	0.181***
	(0.041)	(0.030)	(0.042)	(0.028)
Ln(PC)	0.690***	0.211***	0.679***	0.172***
	(0.029)	(0.023)	(0.030)	(0.021)
Ln(HC)	-0.005	0.274	0.033	0.421
	(0.149)	(0.219)	(0.153)	(0.305)
Ln(URN)	0.200***	0.272*	0.191***	-0.187
	(0.050)	(0.157)	(0.051)	(0.149)
Ln(OPN)	0.146***	0.140***	0.159***	0.308***
	(0.024)	(0.019)	(0.025)	(0.025)
Ln(INS)	0.236***	0.057	0.250***	-0.025
	(0.049)	(0.046)	(0.050)	(0.042)
Ln(RTA)	0.004	0.051***	0.002	0.048***
	(0.010)	(0.015)	(0.010)	(0.014)
Constant	-1.249**	1.906**	-1.239**	2.642**
	(0.525)	(0.743)	(0.533)	(1.171)
Observations	385	385	385	385
Adjusted R2	0.971	0.997	0.971	0.998
C_FE	No	Yes	No	Yes
T_FE	NO	No	Yes	Yes

Source: Author's own calculation. Standard errors are reported in parentheses. *** $p<0.01$, ** $p<0.05$ and * $p<0.1$ indicate the 1%, 5% and 10% level of significance, respectively. Where C_FE represents country fixed effects (cross section) and T_FE indicates time (year) fixed effects.

After selecting SDPM, this study uses the Hausman test to choose between the fixed and random effect models. Based on the Hausman test, the prefer model is SDPM with fixed effects. The results for the SDPM are reported in Table 4, which contains the point estimates of the growth model using four different specifications. First specification considers the role of infrastructure (INF) along with physical capital (PC), human capital (HC) and urbanization (URN) variables as control variables. In second specification, the model is expanded to quantify the role of openness (OPN) as a measure of regional integration. Third specification measures the impact of institutions (INS) apart from other variables mentioned above. While last specification considers an alternative proxy of regional integration, namely regional trade agreements (RTA). In table 5, direct, indirect and total effects are reported based on estimation results presented in table 4 for the SDPM.

It is worth mentioning that the parameter of spatial autocorrelation i.e. ρ is statistically significant at 1% level in all specifications, signifying the presence of spatial dependence in the data. The results show the positive impacts of the spatial lag of the dependent variable ranges from 0.22 to 0.34. The estimated impacts are statistically significant at 1% level in all specifications. This implies that the weighted average of the GDP per capital of neighbor countries positively influences the economic development in the regions under analysis. A 10% increase in GDP per capita of neighboring countries would lead to 2% to 3% increases in GDP per capita of a particular country. This finding is in accordance with previous literature (Ahmad & Hall, 2017; Arbués et al., 2015). Economic development in other countries would generate demand for goods and services in a particular country which leads to higher economic growth. Economic agents in a particular country would increase the capacity utilization to meet neighboring countries demand when GDP in other countries grows.

The impacts of independent variables on economic development of a country are explained using direct, indirect and total effects reported in Table 5. The estimation results show that infrastructure has a positive and significant direct impact on economic development. The direct elasticities of infrastructure range from 0.14 to 0.19 and are statistically significant at 1% level in all specifications. This shows a 10% increase in infrastructure would lead to 1.4% to 1.9% increases in GDP per capita of region. Infrastructure also has positive and significant spillover effect. The indirect elasticity of infrastructure is 0.02 and is statistically significant at 10% level most of the specifications implying that a 10% increase in infrastructure of neighboring countries would lead to 0.2% increases in GDP per capita of a particular country. The overall (total) impact of infrastructure on economic growth is positive and statistically significant. The positive direct and spillover effects are supported by various studies (Arbués et al., 2015; Chen & Haynes, 2015b; Dehghan Shabani & Safaie, 2018; C. F. Del Bo & Florio, 2012; Li et al., 2017; Ojede et al., 2018; Yu et al., 2013).

Provision of efficient infrastructure improves market linkages, reduces transportation costs and enhances labor productivity. All these factors would lead to higher economic growth. The significant economic contribution of infrastructure supports the economic policies of the Asian region which relies on infrastructure development for sustained economic growth. Asia, being most populous continents with high poverty, requires long term high and sustained economic to manage its population needs, eliminate poverty and achieve sustainable development goals[16]. Infrastructure investment is a “big push” for these economies to uplift their status and to complete economic transition process. Asian economies are investing over 8% of GDP in infrastructure, mainly financed by the public sector. Empirical findings support this investment to achieve economic development and eliminate poverty.

The direct impacts of physical capital and human capital on the output of a particular country are positive and statistically significant. The elasticities of physical capital (between 0.22 and 0.29) and human capital (ranges from 0.41 to 0.57) are positive and significant in most of the

[16] Around 60% of the world’s population (4.4 billion in 2016) is living in Asia.

specifications at 1% level. These estimates are similar to those reported in various studies (Ahmad & Hall, 2017; Márquez, Ramajo, & Hewings, 2010). The spillover effects i.e. indirect impacts of physical capital and human capital are also positive and statistically significant in most cases. The elasticities range from 0.06 to 0.09 and 0.54 to 0.62 of physical capital and human capital, respectively. The magnitudes of spillover effects of physical and human capitals provide interesting economic implications. The human capital not only have higher direct impact but also have higher spillover effects compared to physical capital. A 10% increase in human capital of neighboring countries would lead to 5% increases in GDP per capita of a particular country while physical capital only causes 0.6%. Availability of productive and healthier labor from neighboring countries along with easy across boarder mobility act as source of technological transfer. This leads to multiplier effect on the economic development of a specific country. This also supported the "labor migration" argument (Boarnet, 1998; Ozbay et al., 2007). Labor migration is a common feature of Asian economies especially from South Asian region to Middle East. Urbanization has a direct positive impact and insignificant spillover effects. The direct elasticity of urbanization is 0.4 which is significant in most of the specifications at 1% level. Literature supported this finding by arguing that urbanization is the engine and major driving force of economic growth. It allows agglomeration of people and firms and economies of scales. This reduces transactions costs and hence increase economic output (Arouri, Youssef, Nguyen-Viet, & Soucat, 2014; Bertinelli & Black, 2004).

The direct impact of trade openness is positive and statistically significant in most of the specifications. The results show that 10% increase in openness would lead to 1.8% of economic output in Asian regions. Apart from this, we use regional trade agreements as a proxy of regional integration. We find a direct positive and statistically significant impact on economic development. A 10% increase in regional trade agreements would leads to 0.5% increase in economic output of the region. Numerous studies have found positive association between openness and economic growth (Edwards, 1998; Fetahi-Vehapi et al., 2015; Frankel & Romer, 1999; Freund & Bolaky, 2008; Keho, 2017; Tumwebaze & Ijjo, 2015). Interestingly spillover effects turned out to be negative in case of openness and regional trade agreements. The estimation results show that a 10% increase in openness in neighboring countries would lead to a 0.7% decline in economic output of particular country. Similar results are found for regional trade agreements variable. It is also argued that spillover effects of regional integration are conditioned to other factors namely initial GDP per capital, investment environment and institutional setup of the country. Differences in trading patterns and low capacity to specialize in production process provide leads to negative spillover effects of trade and regional integration (Hausmann, Hwang, & Rodrik, 2007).

Table 4: Results of Spatial Durbin Panel Model (SDPM)

Variables	Model 1	Model 2	Model 3	Model 4
ρ	0.072***	0.064***	0.063***	0.068***
	(0.003)	(0.002)	(0.002)	(0.003)
Ln(INF)	0.190***	0.148***	0.145***	0.192***
	(0.032)	(0.029)	(0.029)	(0.031)
Ln(PC)	0.279***	0.215***	0.199***	0.283***
	(0.021)	(0.019)	(0.021)	(0.020)
Ln(HC)	0.555**	0.304	0.504**	0.110
	(0.241)	(0.214)	(0.213)	(0.239)
Ln(URN)	0.442***	0.024	0.022	0.432**
	(0.171)	(0.157)	(0.160)	(0.168)
Ln(OPN)		0.197***	0.193***	
		(0.020)	(0.020)	
Ln(INS)			0.073*	
			(0.044)	
Ln(RTA)				0.073***
				(0.015)
W*Ln(INF)	0.000	-0.111*	-0.101	-0.015
	(0.075)	(0.067)	(0.067)	(0.072)
W*Ln(PC)	0.083*	0.124***	0.136***	0.097*
	(0.051)	(0.047)	(0.051)	(0.050)
W*Ln(HC)	0.204	1.164**	1.173**	1.128**
	(0.563)	(0.513)	(0.512)	(0.553)
W*Ln(URN)	-0.420	-0.343	-0.442	-0.412
	(0.300)	(0.264)	(0.270)	(0.284)
W*Ln(OPN)		-0.211***	-0.203***	
		(0.039)	(0.039)	
W*Ln(INS)			0.018	
			(0.085)	
W*Ln(RTA)				-0.214***
				(0.042)
W*Ln(GDP)	0.219***	0.338***	0.339***	0.292***
	(0.080)	(0.075)	(0.075)	(0.077)
^Wald Test of spatial terms	[27.9](0.00)	[67.4](0.00)	[68.8](0.00)	[59.6](0.00)

Source: Author's own calculation. Standard errors are reported in parentheses. *** p<0.01, ** p<0.05 and * p<0.1 indicate the 1%, 5% and 10% level of significance, respectively. ^Chi2 values are reported brackets [] while Prob > chi2 is reported in parentheses ().

The total impact of institutions on economic output is positive and statistically significant. The direct elasticity of institutions is 0.07 (statistically significant at 10% level) implying that a 10% increase in institutional quality would leads to 0.7% increases in GDP per capita of region. The positive and direct association between institutions and economic growth is well supported in empirical literature (Ahmad & Hall, 2017; Arbia, Battisti, & Di Vaio, 2010). However, the spillover effect of institutions is positive but statistically insignificant. Various studies have found insignificant spillover effects of institutions on economic growth (Arbia et al., 2010; Claeys & Manca, 2011; Faber & Gerritse, 2009).

Table 5: Direct, Indirect and Total Effect based on SDPM

Variables	Model 1		Model 2		Model 3		Model 4	
	Coefficients	P-Values	Coefficients	P-Values	Coefficients	P-Values	Coefficients	P-Values
Direct Impact								
Ln(INF)	0.192***	0.000	0.143***	0.000	0.141***	0.000	0.195***	0.000
Ln(PC)	0.286***	0.000	0.231***	0.000	0.216***	0.000	0.296***	0.000
Ln(HC)	0.572**	0.018	0.409*	0.062	0.410**	0.060	0.192	0.421
Ln(URN)	0.426**	0.015	-0.004	0.982	-0.014	0.934	0.411**	0.018
Ln(OPN)			0.185***	0.000	0.182***	0.000		
Ln(INS)					0.073*	0.100		
Ln(RTA)							0.059***	0.000
Indirect Impact								
Ln(INF)	0.019*	0.064	-0.030	0.359	-0.025	0.433	0.019*	0.058
Ln(PC)	0.065***	0.001	0.096***	0.000	0.099***	0.000	0.084***	0.000
Ln(HC)	0.147	0.553	0.616**	0.012	0.622**	0.011	0.547**	0.030
Ln(URN)	-0.145	0.287	-0.163	0.220	-0.212	0.119	-0.135	0.324
Ln(OPN)			-0.070***	0.000	-0.067***	0.000		
Ln(INS)					0.003	0.941		
Ln(RTA)							-0.091***	0.000
Total impact								
Ln(INF)	0.211***	0.000	0.113**	0.031	0.115**	0.029	0.215***	0.000
Ln(PC)	0.351***	0.000	0.326***	0.000	0.315***	0.000	0.380***	0.000
Ln(HC)	0.719**	0.042	1.025**	0.004	1.032***	0.004	0.739**	0.037
Ln(URN)	0.280	0.255	-0.167	0.495	-0.225	0.364	0.277	0.277
Ln(OPN)			0.115***	0.000	0.115***	0.000		
Ln(INS)					0.077**	0.044		
Ln(RTA)							-0.031	0.249

Source: Author's own calculation based on point estimates reported in Table 4. *** p<0.01, ** p<0.05 and * p<0.1 indicate the 1%, 5% and 10% level of significance, respectively.

The discussion presented above reveals a positive direct and spillover effect of infrastructure on regional economies. Various studies argue that the quality of infrastructure is as important as the quantity of infrastructure (Calderón & Chong, 2004; Ismail & Mahyideen, 2015). To further look at the relative importance of quality vs. quality of infrastructure, this study estimates separate models with quality of infrastructure index and quantity of infrastructure index. It provides empirical evidence on the relative importance of infrastructure quality vs. quantity in promoting regional growth.

The estimated results are reported in Table 6 and impacts are reported in Table 7. The total impact of both quality and quantity of infrastructure indices are positive and statistically significant. The direct elasticity of quality of infrastructure index is 0.14 (statistically significant at 1% level) while quantity of infrastructure index is 0.03 (statistically significant at 5% level). This implies that an improved infrastructure quality and an increase in the volume of infrastructure had a positive impact on economic growth of the Asian region. Various studies have reported a positive impact of both quality and quantity of infrastructure on economic growth (Calderón et al., 2015; Ismail & Mahyideen, 2015). The direct elasticity estimates show that a 10% increase in quality of infrastructure index would lead to 1.4% increase in economic development while quantity of infrastructure index would lead to only 0.3% increase in economic development. This suggests that quality of infrastructure leads to higher economic growth than quantity of infrastructure within the region or country. The higher contribution of quality of infrastructure compared to quantity of infrastructure is also reported for selected Asian economies (Ismail & Mahyideen, 2015). Quality reduces the maintenance transportation cost, thus leading to higher worker productivity and economic growth. Insufficient and low performing infrastructure may cause impediments in economic activities hence economy may not operate at full potential. In essence, availability of sufficient infrastructure is very important to promote economic development; however, quality of infrastructure is crucial for economic competitiveness, hence has relatively greater contribution in achieving sustainable development.

Table 6: Results of Spatial Durbin Panel Model (SDPM) (Quality vs. Quantity)

Variables	Model 1	Model 2
	Quality of INF	Quantity of INF
ρ	0.073***	0.075***
	(0.003)	(0.003)
Ln(INF)	0.144***	0.029**
	(0.028)	(0.014)
Ln(PC)	0.281***	0.281***
	(0.021)	(0.022)
Ln(HC)	0.745***	0.712***
	(0.236)	(0.264)
Ln(URN)	0.411**	0.489***
	(0.169)	(0.182)
W*Ln(INF)	-0.025	0.097*
	(0.062)	(0.051)
W*Ln(PC)	0.084	0.099*
	(0.051)	(0.051)
W*Ln(HC)	0.544	0.385
	(0.517)	(0.562)
W*Ln(URN)	-0.573*	-0.842**
	(0.301)	(0.338)
W*Ln(GDP)	0.229***	0.201***
	(0.080)	(0.078)
^Wald test of spatial terms	30.86(0.00)	38.09(0.00)

Source: Author's own calculation. Standard errors are reported in parentheses. *** p<0.01, ** p<0.05 and * p<0.1 indicate the 1%, 5% and 10% level of significance, respectively. ^Chi2 values are reported brackets [] while Prob > chi2 is reported in parentheses ().

The indirect elasticity of quality of infrastructure index is 0.004 (statistically insignificant) while quantity of infrastructure index is 0.04 (statistically significant at 10% level). This implies that an improved infrastructure quality in the neighboring countries may not have significant impact on economic growth of a specific countries but an increase in the volume of infrastructure in the neighboring countries may have a positive impact on the economic development of a particular country. A 10% increase in quantity of infrastructure index in the neighboring countries would lead to a 0.4% increase in economic development of a specific country. This analysis has an important growth implication. Increase in physical infrastructure stock provides better regional connectivity hence leads to higher economic growth while the benefits on improved quality may not be accessible to other countries hence improve growth within the country. This implies that quantity of infrastructure is more beneficial for regions while quality of infrastructure more fruitful for country itself.

Table 7: Direct, Indirect and Total Effect based on SDPM

	Quality of INF		Quantity of INF	
	Coefficients	P-Values	Coefficients	P-Values
Direct Impact				
Ln(INF)	0.145***	0.000	0.034**	0.019
Ln(PC)	0.289***	0.000	0.288***	0.000
Ln(HC)	0.783***	0.001	0.737***	0.005
Ln(URN)	0.385**	0.025	0.454**	0.013
Indirect Impact				
Ln(INF)	0.004	0.898	0.043*	0.100
Ln(PC)	0.067***	0.001	0.069***	0.001
Ln(HC)	0.324	0.145	0.235	0.324
Ln(URN)	-0.217	0.115	-0.332**	0.027
Total Impact				
Ln(INF)	0.148***	0.001	0.077**	0.018
Ln(PC)	0.355***	0.000	0.357***	0.000
Ln(HC)	1.107***	0.000	0.972***	0.006
Ln(URN)	0.168	0.495	0.122	0.620

Source: Author's own calculation based on point estimates reported in Table 6. *** p<0.01, ** p<0.05 and * p<0.1 indicate the 1%, 5% and 10% level of significance, respectively.

As discussed earlier, the spillover effects of infrastructure may have a significant on economic growth if supported by well-designed institutional framework and regional integration. To empirically test these arguments, this study has estimated SDPM using interaction term of infrastructure with institutions and regional integration. The summary of results is reported in Table 8[17]. The empirical analysis reveals that institutions and regional integration play significant role in making spillover effects operative. The estimated results show that direct impact of overall infrastructure has a positive and significant impact on regional development when supported by well-designed institutional framework and regional integration. Furthermore, both quality and quantity indicators have a significant positive relation with regional development. The indirect elasticity of infrastructure index is 0.009 (statistically significant at the 10% level) when supported by institutions and 0.19 (statistically significant at the 1% level) when accompanied by regional integration representing the positive spillover effects of infrastructure. A 10% increase in

[17] The detailed estimation results are available with authors.

infrastructure index in the neighboring countries would lead to a 0.01% increase in economic development of a specific country when backed by institutions and 1.9% when complemented regional integration. The spillover effects of quantity of infrastructure index become significant when complemented by institutions and regional integration. This indicates that fundamental factors help to direct the spillover effects. Various studies signify the role of underlying factors while studying the growth effects of infrastructure (Calderon et al., 2018; Esfahani & Ramírez, 2003; Robson, 1998). The underlying aspects of economic growth should be considered while devising regional policies especially development of economic corridors based on mega infrastructure projects. It helps to uncover the mechanism through which these factors shape the infrastructure performance. Regional integration provides a policy cover to use the infrastructure across borders, hence generate spillover effects. This analysis reveals that institutions and regional integration act as a catalyst to enhance spillover of infrastructure development.

Table 8: Direct, Indirect and Total Effect based on SDPM

Variables	Overall INF		Quality of INF		Quantity of INF	
	Coefficients	P-Values	Coefficients	P-Values	Coefficients	P-Values
Direct Impact						
Ln(INS)*Ln(INF)	0.038***	0.000	0.030***	0.000	0.007*	0.058
Ln(RTA)*Ln(INF)	0.015***	0.000	0.014***	0.000	0.015***	0.000
Indirect Impact						
Ln(INS)*Ln(INF)	0.009*	0.087	0.007*	0.092	0.003**	0.047
Ln(RTA)*Ln(INF)	0.019***	0.000	0.017***	0.000	0.014**	0.013
Total Impact						
Ln(INS)*Ln(INF)	0.047**	0.030	0.037**	0.047	0.010*	0.078
Ln(RTA)*Ln(INF)	0.034***	0.003	0.031**	0.048	0.029**	0.039

Source: Author's own calculation. *** $p<0.01$, ** $p<0.05$ and * $p<0.1$ indicate the 1%, 5% and 10% level of significance, respectively.

5.1.Robustness Checks

To establish robustness of results, we test alternative specifications and also control for endogeneity. First, we apply SYS-GMM to address endogeneity. Lagged values of all explanatory variables are used as instruments. The results are reported in Table 9. The results show that infrastructure has positive and significant impact on regional economic growth. The results are similar as reported in case of fixed effect estimation. To further control the spatial differences, inverse distance weighted matrix is also used. Various studies supported the use of different weighted matrix and GMM to establish the robustness of results (Arbués et al., 2015). The results of fixed effect with inverse distance weighted matrix are reported in Table 9. The direction and significance level remain same for infrastructure variable. This implies that results are robust regardless of any specification. It can be concluded that despite controlling for endogeneity and applying different weighted matrix, the positive contribution of infrastructure remained significant.

Table 9: Results of Spatial Durbin Panel Model (SDPM) with SYS-GMM

Variables	W_I_Distance	SYS-GMM
ρ	0.071***	0.075***
	(0.003)	(0.003)
Ln(INF)	0.224***	0.090***
	(0.032)	(0.022)
Ln(PC)	0.249***	0.096***
	(0.021)	(0.015)
Ln(HC)	0.337	0.081
	(0.326)	(0.097)
Ln(URN)	0.281*	0.211***
	(0.169)	(0.044)
W*Ln(INF)	0.323*	0.075
	(0.172)	(0.035)**
W*Ln(PC)	0.182**	-0.031
	(0.085)	(0.029)
W*Ln(HC)	-3.094***	-0.190**
	(0.869)	(0.084)
W*Ln(URN)	2.041**	0.333***
	(0.904)	(0.119)
W*Ln(GDP)	0.317**	
	(0.135)	
Ln(GDP-1)		0.750***
		0.025
^Wald test of spatial terms	44.10(0.00)	8.10(0.00)

Source: Author's own calculation. Standard errors are reported in parentheses. *** p<0.01, ** p<0.05 and * p<0.1 indicate the 1%, 5% and 10% level of significance, respectively. ^Chi2 values are reported brackets [] while Prob >

To further judge robustness of results, we have estimated the impact of each indicator along with other control variables as done in many studies. We find that various infrastructure indicators especially road and internet connectivity have significant positive impact on regional economic development (Table 10)[18]. Numerous studies have reported positive and significant contribution of road infrastructure (Arbués et al., 2015; Chen & Haynes, 2015b; Dehghan Shabani & Safaie, 2018; Li et al., 2017). For other infrastructure indicators like port and telephone would not generate robust spillover effects. These outcomes offer varying spatial spillovers for the different mod of infrastructure. Arbués et al., (2015) also find similar results for Spain. Utilizing a production function, Moreno & López-Bazo (2007) found the existence of negative spatial spillovers for transportation infrastructure development.

Table 10: Direct, Indirect and Total Effect based on SDPM (Component Wise)

Variables	Quality of INF	Quantity of INF

[18] The detailed estimation results are available with authors.

	Ln(Elec)	Ln(Port)	Ln(Road)	Ln(Tele)	Ln(EPC)	Ln(Broad)	Ln(Air)
				Direct impact			
Ln(INF)	0.021*	-0.015	0.031***	0.010	0.002	0.022***	-0.012**
Ln(PC)	0.287***	0.288***	0.284***	0.288***	0.284***	0.284***	0.288***
Ln(HC)	1.021***	0.998***	0.917***	1.070***	0.957***	0.340	1.027***
Ln(URN)	0.386**	0.400**	0.301*	0.336*	0.460**	0.535**	0.398**
				Indirect impact			
Ln(INF)	0.011	-0.019	-0.049**	-0.053**	-0.036	0.011*	-0.004
Ln(PC)	0.071***	0.068***	0.076***	0.080***	0.096***	0.069***	0.067***
Ln(HC)	0.382*	0.450**	0.734***	0.399**	0.524***	-0.166	0.475**
Ln(URN)	-0.261**	-0.227	-0.353**	-0.390***	-0.260*	-0.146	-0.252*
				Total impact			
Ln(INF)	0.032*	-0.034*	0.018**	-0.043	-0.034	0.033***	-0.016**
Ln(PC)	0.358***	0.356***	0.360***	0.368***	0.380***	0.352***	0.355***
Ln(HC)	1.403***	1.448***	1.651***	1.469***	1.481***	0.175	1.502***
Ln(URN)	0.125	0.173	-0.052	-0.055	0.201	0.389	0.145

Source: Author's own calculation. *** p<0.01, ** p<0.05 and * p<0.1 indicate the 1%, 5% and 10% level of significance, respectively.

6. Concluding remarks and policy implications

This study investigated the impact of spillover effects of the infrastructure on economic growth after controlling institutions and regional integration for Asian economies. More specifically, this study examined the relative spillover effects of quantity and quality dimensions of infrastructure. In addition, it examined the complementarity of the infrastructure with the institutions and the regional integration to channel spillover effects. An augmented spatial endogenous growth model is developed to illustrate the complementarity of the infrastructure with the institutions and the regional integration in defining the spillover effects of infrastructure. Infrastructure is a multidimensional concept. This study developed a multidimensional infrastructure index using the Alkire and Foster method that includes quantitative and qualitative dimensions. The quantity is captured using telecom, power, broadband and air, while quality is based on electricity, port and road. Using this index, an empirical analysis is performed based on the Spatial Durbin Panel Model (SDPM) for a group of 35 Asian economies over the period 2006-2016. Moreover, to address the possibility of endogeneity and to guarantee the robustness of the results, this study used the SYS-GMM.

The results show that the infrastructure has a positive and significant direct impact on regional economic development. The direct elasticities of the infrastructure range between 0.14 and 0.19, which show that a 10% increase in infrastructure would lead to an increase of 1.4% to 1.9% of GDP per capita in the region. The infrastructure also has a positive and significant spillover effect. The indirect elasticity of 0.02 implies that a 10% increase in the infrastructure of neighboring countries would lead to an increase of 0.2% of GDP per capita in a particular country.

The spillover effects of physical and human capitals are positive and statistically significant. Elasticities range from 0.06 to 0.09 and 0.54 to 0.62 of physical and human capitals, respectively. Human capital has greater spillover effects than physical capital. The direct impact of trade openness is positive and statistically significant, indicating that a 10% increase in openness would leads to a 0.5% increase in the region's economic output. The total impact of the institutions on economic output is positive and statistically significant. The direct elasticity of institutions is 0.07 implying that a 10% increase in institutional quality would leads to a 0.7% increases in GDP per capita in the region.

To further look at the relative importance of quality and quantity of infrastructure, separate models for both indicators are estimated. The total impacts of both indicators are positive and statistically significant. Estimates of direct elasticity show that a 10% increase in quality of infrastructure would lead to an increase of 1.4% in economic development while the amount of infrastructure leads to an increase of 0.3% in economic development. This suggests that the quality of infrastructure leads to greater economic growth than the amount of infrastructure within the region or country. The indirect elasticity of quality of infrastructure is statistically insignificant while quantity of infrastructure is statistically significant. This implies that an improved infrastructure quality in the neighboring countries may not have significant impact on economic growth of a specific countries but an increase in the volume of infrastructure in the neighboring countries can have a positive impact on the economic development of a given country. The increase in physical infrastructure stock provides better regional connectivity, therefore, leads to higher economic growth, while the benefits of better quality may not be accessed by other countries and, consequently, only improve the growth within the country. This shows that the amount of infrastructure is more advantageous for the regions, whereas the quality is more fruitful for the country.

Furthermore, the analysis confirms the complementarity of the infrastructure with the institutions and the regional integration, which implies that these factors act as a stimulus to improve the spillover effects of the infrastructure. The estimated results show that infrastructure has a positive and significant direct effect on regional development when supported by well-designed institutional framework and regional integration. The empirical analysis, further, show that both quality and quantity indicators have a significant positive relationship with regional development. The spillover effects of quantity of infrastructure index become significant when complemented by institutions and regional integration. This indicates that fundamental factors help to direct the spillover effects.

This analysis supports infrastructure development policies to achieve sustained economic growth in Asia. The infrastructure investment schemes over the past two decades reveal that Asian countries are heavily dependent on developing infrastructure for sustained economic growth. Infrastructure is a "big push" for these economies to uplift their economic status and eliminate poverty. The complementarity role of institutions and regional integration necessitate the consideration of these factors in planning infrastructure development policies, in particular the economic corridors throughout Asia.

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Appendix

Appendix Table 1: Summary of available literature

INF Measure	Other variables	Area/time	Theoretical framework	Estimation Methodology	Spillover effect	Source
Street-and-highway capital stock	Employment Private capital stocks	California counties, USA [1969–1988]	LL(CDPF)	SLM	-ve	(Boarnet, 1998)
Public capital expenditure	Labor Private capital expenditure GDP deflator	USA, Canada [1960-1995]	LL(CDPF)	OLS	+ve	(Owyong & Thangavelu, 2001)
Public capital in transportation and communication	Employment Private capital	17 Spanish communities [1970-1995]	Regression model	VAR	+ve	(Pereira & Roca-Sagalés, 2003)
Public investment in highways	Employment Private capital	48 States, USA [1977–1999]	Regression model	VAR	+ve	(Pereira* & Andraz, 2004)
Roads Ports Airports Railways	Labor Private capital	17 Spanish regions [1965–1995]	LL(CDPF)	FE-IV	+ve	(Cantos et al., 2005)
Highway capital	Employment Private capital	State, county and municipality, USA [1990-2000]	LL(CDPF)	OLS	+ve	(Berechman et al., 2006)
Local infrastructure Transport	Capital stock Labor force	Spanish provinces [1965-1997]	LL(CDPF)	FE, SLM	-ve	(Moreno & López-Bazo, 2007)
Transportation Capital stock	Labor Private capital Other public capital stock	Chinese provinces [1993-2004]	LL(CDPF)	RE with spatial weights	+ve -ve (mix)	(Xueliang, 2008)
Transportation Capital stock	Private Capital Labor	Chinese provinces [1985-2006]	LL(CDPF)	SAR, SMA	+ve	(Hu & Liu, 2010)
Highway capital stock	Private capital Employment Urbanization	48 States, USA [1984–1997]	LL(CDPF)	FE and SYS-GMM	+ve	(Jiwattanakulpaisarn et al., 2011)
Motorways Roads Electrified rail lines Broadband Websites Internet Multimodal accessibility Time to market Interregional trips by trucks	Capital stock Labor force Human capital	262 European NUTS2 regions in 2006	LL(CDPF)	OLS, TSLS, SDM	+ve	(C. F. Del Bo & Florio, 2012)
Transport investment	Private capital Employed labor force Public capital	Chinese provinces [1978–2009]	LL(CDPF)	SDM	+ve -ve (mix)	(Yu et al., 2013)
Transport infrastructure investment	Fixed assets investment Labor force	Chinese provinces [1990-2010]	Feder model	SEM, SLM	+ve	(Wang et al., 2014)

Road Railways Airports Ports	Capital stock Labor force Human capital	Spanish provinces [1986-2006]	LL(CDPF)	SDM	+ve	(Arbués et al., 2015)
Highway Railway Transit	Employment Private capital	USA States [1991-2009]	LL(CDPF)	OLS, SEM, SAR, SDM	+ve	(Chen & Haynes, 2015b)
Transport capital stock	Employment Private capital	Spanish provinces [1980-2007]	LL(CDPF)	SAR, SARAR	+ve	(Álvarez, Condeço-Melhorado, Gutiérrez, & Zofío, 2016)
Infrastructure capital stock (internal & imported capital)	Employment Private capital	Spanish provinces [1980-2007]	LL(CDPF)	FE	+ve -ve (mix)	(Álvarez, Barbero, & Zofío, 2016)
Railway Highway	Investment Human Capital Labor openness	Chinese provinces [2005-2014]	Regression model	OLS, SLM, SEM, SDM	+ve	(Li et al., 2017)
Road Railway	Concentration of industrial activities Real capital stock	Iranian provinces [2001-2011]	LL(CDPF)	SDM	+ve	(Dehghan Shabani & Safaie, 2018)
Highway infrastructure	Private investment Private non-farm employment Unions Education Expenditure State and local deficit State and local tax burden Individual personal income tax Corporate income tax	USA States [1971-2005]	LL(CDPF)	Dynamic SDM	+ve	(Ojede et al., 2018)

Source: Author's own formulation.

Appendix Table 2: List of countries

Armenia	Japan	Pakistan
Azerbaijan	Jordan	Philippines
Bahrain	Kazakhstan	Qatar
Bangladesh	Korea, Rep.	Russian Federation
Cambodia	Kuwait	Saudi Arabia
China	Kyrgyz Republic	Singapore
Egypt, Arab Rep.	Lebanon	Sri Lanka
Georgia	Malaysia	Tajikistan
India	Mongolia	Thailand
Indonesia	Myanmar	United Arab Emirates
Iran, Islamic Rep.	Nepal	Vietnam
Israel	Oman	

Source: Author's own formulation.

Appendix Table 3: Variable definition

Variables	Definition	Source
Infrastructure (INF)	Quantity of infrastructure: 1. Fixed telephone subscriptions (per 100 people) 2. Electric power consumption (kWh per capita) 3. Fixed broadband subscriptions (per 100 people) 4. Air transport, freight (million ton-km) Quality of infrastructure 1. Quality of electricity supply 2. Quality of port infrastructure 3. Quality of Road infrastructure	WDI & WEF
GDP per worker (GDP)	GDP (constant 2010 US$) divided by total labor force	WDI
Physical Capital (PC)	Gross fixed capital formation (constant 2010 US$) divided by total labor force	WDI
Human Capital (PC)	1. Education index: Mean year of schooling for adults aged 25 years and more and expected years of schooling for children of school entering age 2. Health index: Life expectancy at birth	UNDP
Urbanization (URN)	Urban population (% of total)	WDI
Openness (OPN)	Merchandise trade divided by total labor force	WDI
Institutions (INS)	1. Voice and accountability (VA) 2. Political stability and absence of violence/terrorism (PA) 3. Government effectiveness (GE) 4. Regulatory quality (RQ) 5. Rule of law (RL) 6. Control of corruption (CC) For comprehensive definition of each indicator see Kaufmann et al., (2011)	WGI
Regional trade agreements (RTA)	Regional trade agreements are defined as reciprocal trade agreements between two or more partners. Population adjusted RTA index	WTO

Source: Author's own formulation