The Electricity Journal 33 (2020) 106735

Contents lists available at ScienceDirect

The Electricity Journal

journal homepage: www.elsevier.com/locate/tej

Impact of infrastructure on economic growth in South Asia: Evidence from pooled mean group estimation

Hameed Khan[a,*], Umair Khan[b], Li Jun Jiang[c], Muhamad Asif Khan[d]

[a] Scholar at School of Economics, Jilin University, Changchun, China
[b] Kohat University of Science & Technology, Kohat, Pakistan
[c] Professor at School of Economics, Jilin University, Changchun, China
[d] University of Kotli, Azad Jammu & Kashmir, Pakistan

ARTICLE INFO

JEL classification:
O1
H4
H54
L9

Keywords:
Infrastructure
South Asia
Growth
Pooled mean group

ABSTRACT

We investigate the role of infrastructure in the economic growth of South Asia. To overcome the shortcomings in previous studies, we analyzed the economic growth in a more comprehensive infrastructure framework by introducing a composite index of infrastructure, which includes more than thirty indicators. The pooled mean group estimator' results suggest a positive impact of infrastructure on economic growth. The inclusion of control variables is robust to our analysis. We advocate several policy recommendations.

1. Introduction

The relationship between infrastructure development and economic growth has been a subject of intense enquiry and heated debate (Aschauer, 1989b; Calderón and Servén, 2004). Since the last decade, economic growth in South Asia has been increasing. In the meantime, the infrastructure has also developed. About a quarter of world population is residing in South Asia, and much of the population is still living below poverty line. Similarly, income inequalities within these countries have been raised. It is then a natural question to ask whether the infrastructure development has boosted the economic growth of South Asian countries, or high economic growth in some sense "exceptional" given the infrastructure development. Therefore, our study aims to investigate the role of infrastructure development in economic development of South Asian countries.

Role of infrastructure in economic development has been acknowledged in the previous literature (Aschauer, 1989b; Calderón and Servén, 2004; Canning and Pedroni, 2004; Easterly and Rebelo, 1993; Röller and Waverman, 2001; World Bank, 1998). The infrastructure may enhance economic development and alleviate poverty in multiple ways and channels (Démurger, 2001; Estache and Mondiale, 2008). These channels consist of production facilitation, enhancement of competitiveness through trade facilitation, reduction in the transportation costs, enhancement of trade, and the creation of employment. Contrary to its positive contribution in economic development, the lack of infrastructure may create obstacles to economic growth. Similarly, without the proper infrastructure, poverty may not be alleviated. Hence, it is viewed that improved provision of infrastructure creates competitiveness, efficiency, and productivity.

The poor and less developed infrastructure is one of the critical causes of less economic development and poverty in South Asia. Inadequate public infrastructure acts as a major impediment to business growth in South Asian countries. Therefore, to compete in the globalized world, the South Asian countries need to improve and invest in infrastructure, e.g. energy, transport, internet & communication technology (ICT) and financial sector.

The extant literature is lacking a comprehensive study on the role of infrastructure development in the economic growth and development. Previous studies mainly focused on a single aspect of infrastructure like transportation (Mohmand et al., 2017; Yu et al., 2012). Some other studies incorporated limited number of indicators of physical infrastructure, e.g. energy usage, paved roads, telephone lines, rail density, air transport, etc., which mainly cover the transport, energy, and ICT sectors while ignoring the other aspects of infrastructure, hence may

* Corresponding author at: Kohat University of Science & Technology, Pakistan.
E-mail addresses: hameed.qec@gmail.com (H. Khan), umairk623@gmail.com (U. Khan), lijj@jlu.edu.cn (L.J. Jiang), khanasif82@hotmail.com (M.A. Khan).

https://doi.org/10.1016/j.tej.2020.106735

not present a true picture for policy concerns (Sahoo and Dash, 2009, 2012). Additionally, spending on infrastructure investments are taken as a proxy for infrastructure status in countries, which may not report an accurate picture because the weak institutional quality and poor utilization of infrastructure investment may not be utilized feasibly in the less developed countries such as South Asian countries. South Asian countries have rampant corruption and weak institutional quality, which may affect the infrastructure investments. Therefore, public investment on infrastructure may face threat of expropriation, hence may produce misleading results. Moreover, most of the earlier literature ignored the endogeneity problem and based on either cross-section studies or country-specific time-series studies of a large number of countries.[1]

Addressing the shortcomings in the earlier literature, the current study is taking into account more comprehensive index of infrastructure, which covers 30 indicators consist of transport, energy, ICT, and finance infrastructure. Moreover, the study applies pooled mean group (PMG) estimator that is recently developed and may present an accurate picture of the infrastructure led growth hypothesis. Similarly, we investigate the infrastructure-led growth hypothesis by incorporating the sub-indices of infrastructure. The estimates of PMG approach are superior to the fixed effects estimates, because they are robust to endogeneity (Menegaki, 2019).

Our study is divided into the following sections. Section two describes the stylized facts about economic growth and physical infrastructure in South Asia. Section three shows theoretical framework and data sources. Section four reports the results followed by concluding remarks.

2. Economic development and infrastructure in South Asia

Since independence, South Asian countries introduced various reforms to alleviate poverty and boost economic conditions. The countries are open to the rest of the world and economically integrated. Due to the economic reforms, the economies of South Asia improved much in 1990s. However, worth mentioning is that Pakistan did not progress like other South Asian countries, and the economic system rather got slow in that period. The reasons may be the political instability, the massive influx of Afghan refugees due to Soviet-Afghan war, bad governance, and weak quality of institutions. On the other hand, the remaining South Asian countries did not face such kind of problems and achieved much of economic goals.

In recent years, South Asia is one of the fastest growing regions of the world on the basis of economic growth. The increase in economic growth is credited to the economic reforms in South Asian countries. The economic reforms in 1990s bring economic development in India, Nepal, Sri Lanka, and Bangladesh. However, the desired economic goals are not achieved by Pakistan due to its political instability, social insecurity, and internal conflicts, which interrupt the business climate for investment (Rehman et al., 2020). Specifically, the India's growth surge may be attributed to the pro-market reforms in the early 1990s (LEE and Wie, 2017). Table 1 shows the annual growth rates in South Asian countries based on ten years average growth rates. During 1980–1989, the annual growth rate in Bhutan was the highest in the region with 10.02 %.

Similarly, Pakistan and India also had impressive growth rates in the said duration with 6.86 % and 5.69 %, respectively. It can be seen that these countries have maintained high GDP growth rates during 1990–1999 due to industrial and service sectors. However, the growth rate in Pakistan is slower than the other South Asian countries due to political instability and poor implementation of economic reforms. From 2000–2009, the average annual growth rates are seen to have risen in Bhutan, Bangladesh, India, and Pakistan. It is noteworthy that the growth rates of Nepal and Sri Lanka have fallen in the meantime. Over the fourth decade, the annual growths rates of Pakistan and Bhutan have dropped, while they have risen for the rest of the countries.

Table 1
Average annual growth rates (in percent) in the selected South Asian countries.

Duration	Bhutan	Bangladesh	India	Nepal	Pakistan	Sri Lanka
1980-1989	10.02	3.54	5.69	4.09	6.86	4.15
1990–1999	5.39	4.71	5.77	4.84	3.98	5.26
2000-2009	8.27	5.55	6.90	4.06	4.49	5.00
2010-2017	6.74	6.45	7.26	4.30	4.11	5.81
Overall	6.81	5.51	6.60	4.41	4.20	5.33

Note: Data is sourced from World Bank (2018). *Authors' calculations.*

Meanwhile, macroeconomic variables such as per capita GDP, gross domestic savings, and domestic investments in all the South Asian countries improved except in Pakistan probably due to lack of proper economic reforms. However, the macroeconomic indicators for Pakistan improved very recently.

The infrastructure stock varies among South Asian countries. On country level, it also varies among regions. In 2017, South Asia's economy is grown by 6.55 % (excluding Afghanistan), which is an impressive rate; however, it is lagging behind the developing countries in terms of infrastructure. There is a huge infrastructure gap in South Asia. In monetary terms, the gap is $ 2.5 trillion wide for the next ten years to be covered.[2] The countries in the region need to fill the infrastructure gap to curb the evil of poverty and inequality.

Many people living in South Asia remained unconnected with transportation networks, sound roads, sanitary sewerage disposal, a safe water supply, and a reliable electrical grid. In 2017, the urban population growth rate reached up to 3.80 %, which is less than the growth rate in other developing countries.[3] Still, many people don't have access to electricity. Average access to electricity (% of the population) was 91.25 % in 2016. In Bangladesh, the rate is much lower, and it is recorded 75.92 %. Electricity is an important source of production; hence, without the proper availability of electricity, the economic growth gets worst and ultimately affects poverty.

Similarly, in 2016, SA scored 2.45 % based on logistics performance index (quality of trade and transport-related infrastructure, i.e., 1 = low to 5 = high), which is a moderate and may not be efficient. To take competitive edge, the time and efficient delivery of goods is an important notion in the recent trading world. Moreover, despite the availability of cheap labor, a limited number of foreign firms invested in the region with poor quality of infrastructure. The rate of return on the firm's investment would reduce due to increase in transaction costs.

Table 2 shows the infrastructure capability of SA relative to the developed countries. It can be seen that SA countries are lagging behind the developed countries. The Table 2 indicates that access to electricity in India, which is the biggest country of the region on the basis of population, is much less than the developed countries. The other countries in the regions are also lagging behind the developed nations in access to electricity as percent of population. Moreover, the passenger's density in railways in SA is much higher than the developed countries. Energy use and internet & communication (ICT) are playing a vital role in the economic development through the channels of increased productivity and better know-how. However, we see that energy use and fixed telephone subscriptions are less in SA comparative to Japan, UK, and USA. Countries in the region should strive hard to cover the infrastructure gap to enhance the growth and alleviate poverty.

Since the infrastructure gap is quite huge in the region, therefore,

[1] Notable exceptions are Calderón and Servén (2004); Canning and Pedroni (2004); Fedderke et al. (2006), and Röller and Waverman (2001)

[2] World Bank (2018)

[3] World development (2018)

Table 2
Comparison and gap of infrastructure in 2018.
Source. World Bank (2018)

Countries	Access to electricity (% of population) in 2016	Railways, passengers carried (million passenger-km) in 2015	Fixed telephone subscriptions (per 100 people) in 2017	Energy use (kg of oil equivalent per capita) in 2014
Afghanistan	84.13714		0.334277	
Bangladesh	75.92		0.431281	222.221
Bhutan	100		2.645336	
India	84.52682	1147190	1.734993	637.4286
Maldives	100		4.670089	
Nepal	90.7		2.939086	412.7245
Pakistan	99.14744	20288	1.492388	484.4452
Sri Lanka	95.58823		12.46917	515.6848
Japan	100	206722	50.15599	3470.763
UK	100		50.07535	2776.844
USA	100	10518.69	36.95439	6955.524

the role of infrastructure investment in economic growth is necessary to be examined. For this purpose the dynamic relationship between the two variables are important for both policy making and academic research.

3. Theoretical framework and data

3.1. Theoretical framework

The study aims to investigate the impact of infrastructure on the economic growth of South Asia. Infrastructure enhances trade, export, foreign direct investment, and economic growth. Empirical studies mainly use Cobb-Douglas production function in the neoclassical growth model, and incorporate infrastructure as an input. The infrastructure as an input facilitates labor and capital in the production process. For this purpose, we utilize the augmented Cobb-Douglas production function.

Cobb-Douglas production function has two factors of production, e.g. labor and capital. Capital and labor are used in production processes. Adding infrastructure in Cobb-Douglas production function can assist the two factors of production. The efficiency and productivity both can be improved through the proper provision of public infrastructure. Hence, in the presence of proper infrastructure, the productivity improves. For example, due to an improved network of transportation, the timely delivery of raw materials and the production of final output are efficiently possible. Similarly, the warehousing and logistics facilities help in the production and storing. The above function has various kinds of explanations and perspectives. From the perspective of the neoclassical growth model, there is a constant return to scale as suggested by Solow in 1956. He argues that shocks in infrastructure explain exogenous- and short-run shocks in economic growth. However, the long run effect takes place only due to technology.

Meanwhile, there is an alternative explanation of the above model, i.e. the endogenous growth model. In this model, the infrastructure stock may affect the efficiency of labor and capital, thereby transforming it into increasing- or constant-returns to scale (Romer, 1987). Therefore, shocks to infrastructure can raise the steady-state income per capita in the endogenous growth model.

3.2. Global infrastructure index

We augment the production function by adding foreign direct investment, trade openness, domestic investment, and inflation. This study relies on infrastructure index established by Donaubauer et al. (2016), and it is the main variable of interest. The index is composed of several sub-indices such as transport, energy, ICT, and finance. The authors used more than 30 indicators and applied unobserved component model (UCM) to devise the index, which they name New Global Infrastructure Index.

The global infrastructure index is a powerful comparative to other variable used in the previous researches in the sense that it captures a broader set of indicators and may portray a more accurate picture of the economic performance of countries. Similarly, most of the indicators have missing values, and hence, datasets are unbalanced. Therefore, UCM is a comparatively better approach than the principal component analysis (PCA).

3.3. Data

To analyze the impact of infrastructure on economic growth, we present Table 3 that shows the data sources and descriptive statistics of the variables used in this study. Our dependent variable is GDP growth (annual %). Infrastructure indices are taken from Donaubauer et al. (2016). The indices include transport, energy, internet &

Table 3
Variables' description and sources.

Variable	Notation	Mean	Median	Std. Dev.	Min.	Max.	Data source
GDP growth (annual %)	*GDPG*	5.61	5.32	2.78	−1.55	21.02	WDI (2018)
Global infrastructure index	*GINF*	−0.46	−0.62	0.50	−1.24	0.75	Donaubauer, Meyer, & Nunnenkamp (2015)
Transport infrastructure index	*TINF*	−0.16	−0.43	0.97	−1.37	2.43	
Energy infrastructure index	*EINF*	−0.59	−0.69	0.44	−1.96	0.00	
ICT infrastructure index	*CINF*	−0.73	−0.76	0.33	−1.56	0.00	
Financial infrastructure index	*FINF*	−0.13	−0.12	0.67	−1.35	1.47	
Net inflow of FDI (% of GDP)	*FDI*	0.94	0.76	0.94	−0.44	6.17	WDI (2018)
Trade (% of GDP)	*OPEN*	53.03	47.07	24.94	15.67	93.5	WDI (2018)
Gross fixed capital formation (% of GDP)	*DI*	26.52	23.84	11.37	12.33	68.02	WDI (2018)
Inflation (annual %)	*INF*	7.66	7.51	4.79	−18.11	30.55	WDI (2018)
Higher secondary school enrolment (gross %)	*HC*	49.88	46.91	19.15	11.07	99.69	WDI (2018)

All variables before taking logs. Logs are taken from actual values plus one. The infrastructure data is available from 1990 till 2010; the rest of the data is extrapolated.

telecommunication (ICT), finance, and a global infrastructure index (global infrastructure index includes all the indices). To overcome the data limitations in previous studies, the authors used unobserved component model (UCM) to build the indices.

Following Loayza et al. (2005), we include domestic investment, human capital and trade as our control variables. We also include foreign direct investment (FDI) and inflation as the two affect economic growth. Before proceeding further, it is worth mentioning that institutional quality is an important determinant affecting the economic growth in South Asian countries; however, there is a lack of availability of data for Afghanistan and Nepal. Hence, we drop the institutional quality from our analysis. The descriptive statistics show the measure of central tendency and variability of the data. In this regard, we report mean, median, standard deviation, minimum, and maximum. The mean value of GDP growth, FDI, trade openness, domestic investment, inflation, and human capital are 5.61, 0.94, 53.03, 26.52, 7.66, and 49.88, respectively. It can be seen that the mean and median values of GDP growth and inflation are close to each other, which shows less variability. The minimum value of GDP growth is -1.55 that is due to the bankruptcy of Sri Lanka, where debt reached 101 % of GDP. Furthermore, the Sri Lankan economy was hit by a series of domestic and global economic problems and affected by terrorist attacks.

Similarly, the negative value of FDI as a percent of GDP for Bhutan is due to the fact that it attracts a small amount of foreign capital. In 2017, the foreign capital constitutes -0.44 % of GDP in Bhutan. Moreover, the standard deviation shows the stability of the economy. As far as the underlying variables of our study are concerned, the most unstable variable in this regard is trade openness with 24.94 % while FDI is the most stable variable with low variability.

After the description of descriptive statistics and data sources of the variables, it is imperative to show the correlation among the variables. For this purpose, the correlation matrix is shown in Table 4.

The correlation matrix indicated that transport, energy, ICT, and financial infrastructure have positive correlation with GDP growth. However, the correlation coefficient for global infrastructure is higher (0.487) than the sub-indices of infrastructure. FDI, domestic investment, and human capital have the positive correlation coefficients. However, the correlation coefficients for trade openness and inflation are negative, which implies that trade openness and inflation hurt the economy of South Asia.

3.4. Estimation methodology

In this study, we apply pooled mean (PMG) and mean group (MG) approaches. The PMG approach is proposed by Pesaran, Pesaran et al. (1999). The PMG estimator is associated with pooling and averaging of coefficients over the cross-sectional units. Similarly, Mean Group (MG) estimator is associated with the estimation of each unit separately and averaging them over the cross-sectional units (Pesaran and Shin, 2012). The PMG/MG-ARDL method is applicable to both large and small samples. This is applicable in our study, where we have N = 6 cross sections and T = 21. Similarly, it is applicable for variables that are integrated of I(0), I(1), and mix of both and not for I(2) variables (Pesaran et al., 2001).

To analyze the short and long-run dynamics for the underlying relationship between economic growth and infrastructure, the first step is to establish the stationarity of the variables. If the underlying variables are not stationary, then our results will be spurious and biased. There is a need to check the time series properties of the variables. For this purpose, we apply Phillip-Perron (Phillips and Perron, 1988), Augmented Dickey-Fuller (Dickey and Fuller, 1979), IPS (Im et al., 2003), and LLC (Levin et al., 2002) panel unit root tests in order to identify the order of integration and stationarity of the underlying variables in our study.

However, the mentioned tests are the first generation and thus have their drawbacks like they exhibit important size distortions and low power in the presence of cross-sectional dependence. Hence, in the presence of cross-sectional dependence, we go for the 2^{nd} generation unit root tests. South Asian countries have similarities in many aspects; therefore, cross-sectional dependence may arise. There is the need to, first of all, perform the tests of cross-sectional dependence test to ensure that the cross sections in the panel data analysis are independent for consistent coefficient estimates (Pesaran, 2004). We adopt the cross-section dependence (CD) that supports smaller cross-section (N) and longer time series (T) like this study with $N = 6 < T = 16$. If we find cross-sectional dependence, then we opt for second generation unit root test.

After knowing the order of integration of the variables and cross-sectional dependence, the next step is to apply Kao (1999) and Pedroni (1999) panel co-integration tests to examine the cointegration among the variables. Pedroni (1999) checks the properties of residual-based tests for the null hypothesis of no co-integration for dynamic panels in which both the short-run dynamics and the long-run slope coefficients are permitted to be heterogeneous across individual members of the panel. Pedroni test considers both pooled within dimension tests and group mean between dimension tests with individual intercept in the test.

If the cointegration is established among the variables, then we apply the PMG technique to know the short and long-run dynamics. Similarly, the error correction term will show the speed of adjustment to restore equilibrium.

4. Results

Table 5 reports the results of panel unit root tests on the residuals. It shows that FINF is not stationary at a level while the rest of the variables are stationary at level. The stationarity implies that FINF follows I (1) while other variables follow I(0).

Next, we move towards the panel cointegration, i.e., Kao (1999) and Pedroni (1999) panel cointegration tests. Table 6 reports the cointegration results. In this regard, we check the cointegration between GDPG and our main explanatory variables of interest, the infrastructure

Table 4
Correlation matrix.

	GDPG	GINF	TINF	EINF	CINF	FINF	FDI	OPEN	DI	INF	HC
GDPG	1										
GINF	0.487	1									
TINF	0.225	0.705	1								
EINF	0.108	−0.143	−0.348	1							
CINF	0.102	−0.135	−0.375	−0.304	1						
FINF	0.323	0.552	0.260	−0.353	0.442	1					
FDI	0.367	0.380	0.040	−0.131	0.190	0.615	1				
OPEN	−0.243	0.082	−0.130	0.638	−0.008	0.015	0.228	1			
DI	0.344	0.472	0.284	0.333	0.133	0.413	0.253	0.700	1		
INF	−0.098	0.054	−0.034	0.036	0.026	0.085	0.238	−0.032	−0.11	1	
HC	0.113	0.223	0.062	0.104	0.147	0.188	0.041	0.283	0.54	−0.16	1

Table 5
Unit root results.

Variables	LLC		IPS		ADF		PP	
	Intercept	trend& intercept	Intercept	trend& intercept	Intercept	trend& intercept	Intercept	trend& intercept
Level								
GDPG	−3.90***	−3.66***	−4.27***	−3.53***	48.35***	38.66***	75.97***	72.43***
CINF	−1.55*	−1.37*	−1.65**	−1.01	23.63*	16.50	31.93***	21.95*
EINF	−8.75***	−8.68***	−5.82***	−6.81***	51.89***	78.02***	29.21***	16.22*
FINF	−1.19	−0.50	−0.64	−0.07	16.46	12.36	18.65	11.99
TINF	−1.32*	−1.56*	−0.38	−1.56*	15.58	21.04*	27.70**	46.23***
GINF	−2.59***	−1.51*	−2.28**	−0.77	26.14**	19.89	50.38***	44.46***
FDI	−2.04**	−1.15	−2.82***	−2.53***	36.31***	31.40***	50.96***	48.24***
OPEN	−1.64*	2.81	−0.62	1.56	16.82	8.41	12.49	8.48
HC	−1.16	−1.71**	2.37	1.22	3.85	5.85	4.203	15.10
INF	−3.92***	−3.10***	−2.91***	−1.84**	31.28***	24.23**	48.19***	45.28***
1st difference								
GDPG	−5.65***	−3.41***	−10.79***	−9.31***	117.43***	94.92***	193.04***	1061.31***
CINF	−7.75***	−6.50***	−8.35***	−7.16***	88.87***	70.036***	138.33***	131.50***
EINF	−5.33***	−3.14***	−6.54***	−4.99***	58.56***	41.95***	105.69***	136.58***
FINF	−3.95***	−2.68***	−5.116***	−4.12***	51.80***	40.85***	111.90***	95.31***
TINF	−9.63***	−7.96***	−10.20***	−8.62***	110.23***	85.25***	163.21***	646.62***
GINF	−7.18***	−6.39***	−9.44***	−9.37***	101.6***	93.36***	181.28***	641.77***
FDI	−6.14***	−4.67***	−7.20***	−5.55***	76.83***	57.40***	152.39***	132.15***
OPEN	−4.19***	−2.82***	−4.95***	−4.92***	52.29***	47.07***	95.69***	86.77***
HC	−1.20	−0.86	−1.44*	−0.74	20.99*	15.542	48.30***	36.88***
INF	−10.9***	−9.41***	−10.1***	−7.26***	111.88***	88.99***	184.1***	495.9***

*** , **, and * show 1%, 5%, and 10 level of significance respectively.

indices with other explanatory variables. Therefore, we have five models. Each model includes individual infrastructure while the last model related to the global infrastructure index. Panel A shows the Pedroni residual cointegration test's results while Panel B reports the results of Kao residual cointegration test. The Pedroni cointegration results show that in 4 out of 7 statistics are significant for Model 1, 2, 3, and 5 where we used TINF, EINF, CINF, and GINF as main variables of interest. However, the Pedroni test for Model 3 is giving 3 significant results out of 7. The Pedroni cointegration results are confirmed by the Kao cointegration tests. Hence, there is a long run relationship between the underlying variables.

After the confirmation of cointegration, we check the short- and long-run dynamics of the relationship between economic growth and infrastructure. Table 7 reports the PMG and MG estimation results. We select the maximum lag length 1 for all the variables according to the Akaike Information Criteria (AIC).

In this regard, we have five models. In Model 1, we include transport infrastructure. From Model 2 to Model 5, we include energy, ICT, financial, and global infrastructure indices, respectively. Hausman test identified that PMG is the best estimator in all the models since the probability value in the specifications are more than 10 % level of significance. For Model 1, we obtain slightly insignificant but positive coefficients of transport infrastructure for both long- and short-run. The results are according to the economic theory, which postulates that transport infrastructure positively affects economic growth through the reduction of trade costs associated with transportation.

From Model 2–5, we obtain significant and positive coefficients of energy, ICT, financial, and global infrastructure for long-run. The results are according to the economic theory, which postulates that transport, energy, ICT, and financial infrastructure positively affect economic growth through improved efficiency and productivity. The long-term investment in public infrastructure such as transport, energy, ICT, and finance sectors are associated with an increased level of know-how, hence improving the productivity and efficiency of all economic sectors. Therefore, the South Asian countries are experiencing economic growth for the past several years.

Regarding the control variables in the long-run, FDI has a significant and positive impact on economic growth only in Model 4. While in short-run, the impact is insignificant but positive. The coefficient of trade openness is significantly positive in Model 3 while it turns out insignificant in rest of the Models. In short-run, the coefficients of trade openness are insignificant and negative. In long-run, the coefficients of domestic investment are significant in Model 2, 3, and 5; however, it becomes insignificant in Model 4. Similarly, the coefficients of domestic investment are significant in Model 2 and 3, while they are significantly positive in Model 4 and 5. The ECT is significantly negative in all the

Table 6
Pedroni and Kao cointegration.

Panel A. Between dimension	Model 1	Model 2	Model 3	Model 4	Model 5
Panel v-Statistic	−0.436	−0.293	−0.391	0.058	0.003
Panel rho-Statistic	−1.753**	−0.797	−1.680*	−1.968**	−2.016**
Panel PP-Statistic	−4.61***	−3.224***	−2.896***	−4.332***	−5.339***
Panel ADF-Stat	−0.590	−1.637*	0.926	0.554	−0.500
Within dimension					
Panel rho-Statistic	−0.461	0.393	0.367	−0.798	0.1120
Panel PP-Statistic	−6.571***	−2.877***	−6.570***	−4.889***	−5.457***
Panel ADF-Stat	−1.880**	−1.516*	−1.625*	−0.468	−3.699***
Panel B.					
Kao cointegration test	−1.251*	−2.631***	−2.636***	−1.285*	−1.291*

*** , **, and * show 1%, 5%, and 10 level of significance respectively.

Table 7
PMG and MG estimation results.

	Model 1		Model 2		Model 3		Model 4		Model 5	
Long-run										
Variables	PMG	MG	PMG	MG	PMG	MG	PMG	MG	PMG	MG
FDI	0.055** (0.03)	0.61 (0.58)	0.124 (0.11)	−0.041 (0.36)	0.116 (0.12)	0.031 (0.26)	0.233** (0.11)	0.791 (1.04)	−0.069 (0.11)	0.721 (0.48)
OPEN	−0.133*** (0.04)	0.533 (1.11)	0.06 (0.12)	0.13 (0.73)	−0.341*** (0.13)	0.396 (0.82)	0.056 (0.12)	−0.399 (0.71)	−0.115 (0.12)	−0.294 (0.86)
DI	0.143** (0.06)	1.36 (1.16)	0.461* (0.24)	0.026 (0.25)	1.215*** (0.23)	1.765* (1.06)	0.276 (0.22)	−2.065 (2.05)	0.848*** (0.18)	−0.594 (0.51)
TINF	0.021 (0.01)	0.268 (0.33)								
EINF			0.138** (0.06)	0.0003 (0.12)						
CINF					0.097*** (0.04)	0.269 (0.35)				
FINF							0.501* (0.27)	0.006 (0.04)		
GINF									0.072*** (0.01)	0.291 (0.26)
Short run										
D.FDI	0.036 (0.2)	−0.142 (0.34)	0.06 (0.12)	0.293 (0.35)	0.107 (0.22)	0.166 (0.28)	0.057 (0.15)	0.337 (0.6)	0.234 (0.14)	0.131 (0.25)
D.OPEN	−0.09 (0.98)	0.222 (0.84)	−0.264 (1.03)	−0.521 (0.87)	−0.435 (1.11)	−0.804 (1.53)	−0.004 (1.02)	−0.743 (1.32)	−0.356 (1.15)	−0.771* (0.41)
D.DI	1.419* (0.8)	2.287*** (0.75)	0.879 (0.69)	1.58*** (0.52)	0.922 (1.24)	2.566*** (0.82)	1.162* (0.65)	3.959** (1.86)	1.499** (0.67)	1.799*** (0.59)
D.TINF	0.611 (0.45)	0.483 (0.53)								
D.EINF			0.02 (0.03)	0.031 (0.24)						
D.CINF					0.13 (0.09)	0.153 (0.13)				
D.FINF							0.006 (0.08)	0.034 (0.21)		
D.GINF									0.093** (0.04)	0.502*** (0.19)
Constant	0.836*** (0.12)	6.675 (6.33)	0.129 (0.09)	−0.062 (3.08)	−0.974*** (0.14)	−1.664 (4.66)	0.508*** (0.05)	7.406 (5.64)	−0.417*** (0.07)	3.451 (4.03)
Error correction term										
ECT	−0.931*** (0.12)	−0.974*** (0.13)	−0.946*** (0.05)	−0.91*** (0.07)	−0.815*** (0.07)	−0.834*** (0.15)	−0.824*** (0.05)	−0.814*** (0.12)	−0.968*** (0.05)	−0.972*** (0.13)
N	147	147	143	143	123	123	146	146	128	128
Hausman	5.03		1.58		4.39		3.52		8.38	
	(0.28)		(0.81)		(0.355)		(0.474)		(0.078)	

Note: standard errors in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table 8
Cross-sectional dependence tests.

Variables	Breusch-Pagan LM	Pesaran (2004) scaled LM test	Baltagi et al. (2012) Bias - corrected scaled LM test	Pesaran (2004) CD test
GDPG	43.911***	3.535***	3.405***	2.650***
TINF	161.952***	21.749***	21.619***	−1.146
CINF	93.833***	11.238***	11.108***	−1.766*
FINF	94.983***	11.415***	11.286***	−1.291
FDI	64.547***	6.719***	6.589***	3.427***
OPEN	148.942***	19.741***	19.612***	−0.573
DI	95.592***	11.509***	11.380***	2.308**
NFI	102.202***	12.529***	12.395***	7.852***
HC	214.475***	29.853***	29.708***	14.109***

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

cases.

The tests results of cross-sectional dependence are shown in Table 8. In this regard, we have following tests, i.e. Breusch-Pagan LM test; Pesaran (2004) scaled LM test; Baltagi, Feng, & Kao (2012) bias-corrected scaled LM test; and Pesaran (2004) CD test. All the tests given in Table 8 show that there is no cross-sectional dependency problem.

Overall, the results are in line with our hypothesis. Moreover, our results are in line with previous literature that supports the investment in public infrastructure (Aschauer, 1989a; Beaudreau, 1995; Menyah et al., 2014; Sahoo and Dash, 2009). It is evident that the elasticity of growth with respect to the global infrastructure index is small. Similarly, the elasticities of sub-indices of infrastructure are also small. The findings are consistent with (Aschauer, 1989a, 1989b). Overall, the results are suggesting that infrastructure is an important of economic development in SA countries. Energy shortage, poor transportation, and poor financial institutions are the causes for poor economic performances and poverty. However, the ICT sector is developing and contributing positively in these countries. To meet the energy requirements of the region, there should be reforms in place. Renewable sources of energy may be handy for these countries. Similarly, private investment should be encouraged to meet the higher needs of the transportation.

5. Conclusion

Since the last decade, economic growth in South Asia has been increasing. In the meantime, the infrastructure has also been developed. About a quarter of world population is residing in South Asia, and much of the population is still living in below the poverty line. Similarly, Income inequality has risen sharply since the 1990s in South Asia. Therefore, our study aims to answer the question: What is the impact of infrastructure stock on the economic growth of South Asian countries?

Previous studies mainly focused on the single aspect of infrastructure such as transportation, paved roads, electricity consumption, telephone lines, etc. Similarly, previous studies focused on public expenditures or the infrastructure investments as a proxy for infrastructure, which may not address the issues clearly and satisfactorily since the weak institutional quality and poor utilization of infrastructure investment may not feasibly be utilized in the less developed countries such as South Asian countries. Moreover, the usage of limited number of indicators may produce misleading results due to omitted variables bias.

Keeping in view the shortcomings in the extant literature, our study aims to investigate the relationship between infrastructure stock and economic by applying comprehensive index of infrastructure, which covers broad spectrum of indicators such as energy, transport, ICT, and finance. To cover the methodological issues ignored in previous studies, we apply PMG approach. Hausman test suggest that PMG is feasible approach. Our results show that there is long-run relationship between infrastructure and GDP growth. Except transport, all the infrastructure indices including the global infrastructure index are significant in the long-run. In the short-run, all the coefficients turn out insignificant except the global infrastructure. We noted that there is no cross-sectional dependency problem.

Based on our findings we are able to put forward several implications for policymakers. Private investment should be encouraged to invest in energy, ICT, transportation, and banking sector to increase efficiency and productivity. Moreover, South Asia is facing acute shortage of energy. To meet the requirement of the industry and general public, the SA countries should invest in renewable energy. Similarly, foreign investors should be encouraged to invest in these sectors by giving them tax rebates and establishing the free economic zones.

This study has focused on the role of infrastructure in economic growth, which is not the only explanation of infrastructure led growth hypothesis. Future research can expand the analysis to more indicators to allow more insights into the impact of the infrastructure on economic growth from this area. Moreover, the income inequality combine with poverty has been rising in these countries. Future research should be focused on the income inequality and poverty in relation with infrastructure.

References

Aschauer, D.A., 1989a. Is public expenditure productive? J. Monet. Econ. 23 (2), 177–200. https://doi.org/10.1016/0304-3932(89)90047-0.
Aschauer, D.A., 1989b. Public Investment and Productivity Growth in the Group of Seven. Economic Perspectives Provided by the Federal Reserve Bank of Chicago, pp. 17–25.
Baltagi, B.H., Feng, Q., Kao, C., 2012. A Lagrange Multiplier test for cross-sectional dependence in a fixed effects panel data model. J. Econom. 170 (1), 164–177. https://doi.org/10.1016/j.jeconom.2012.04.004.
Beaudreau, B.C., 1995. The impact of electric power on productivity. A study of US manufacturing 1950-1984. Energy Econ. 17 (3), 231–236. https://doi.org/10.1016/0140-9883(95)00025-P.
Calderón, C., Servén, L., 2004. The effects of infrastructure development on growth and income distribution. Economia y Empresa. https://doi.org/10.1596/1813-9450-3400.
Canning, D., Pedroni, P., 2004. The Effect of Infrastructure on Long Run Economic Growth. Harvard University, pp. 1–30.
Démurger, S., 2001. Infrastructure Development and Economic Growth: An Explanation for Regional Disparities in China? J. Comp. Econ. 29 (1), 95–117. https://doi.org/10.1006/jcec.2000.1693.
Dickey, D.A., Fuller, W.A., 1979. Distribution of the estimators for autoregressive time series with a unit root. J. Am. Stat. Assoc. 74 (366a), 427–431. https://doi.org/10.1080/01621459.1979.10482531.
Donaubauer, J., Meyer, B.E., Nunnenkamp, P., 2016. A new global index of infrastructure: construction, rankings and applications. World Econ. 39 (2), 236–259. https://doi.org/10.1111/twec.12290.
Easterly, W., Rebelo, S., 1993. Fiscal policy and economic growth. J. Monet. Econ. 32 (3), 417–458. https://doi.org/10.1016/0304-3932(93)90025-B.
Estache, A., Mondiale, B., 2008. Infrastructures et développement: une revue des débats récents et à venir. Rev. Econ. Dev. 21. https://doi.org/10.3917/edd.214.0005.
Fedderke, J.W., Perkins, P., Luiz, J.M., 2006. Infrastructural investment in long-run economic growth: south Africa 1875-2001. World Dev. 34 (6), 1037–1059. https://doi.org/10.1016/j.worlddev.2005.11.004.
Im, K.S., Pesaran, M.H., Shin, Y., 2003. Testing for unit roots in heterogeneous panels. J. Econom. 115 (1), 53–74. https://doi.org/10.1016/S0304-4076(03)00092-7.
Kao, C., 1999. Spurious regression and residual-based tests for cointegration in panel data. J. Econom. 90 (1), 1–44. https://doi.org/10.1016/S0304-4076(98)00023-2.
Lee, J.W., Wie, D., 2017. Wage structure and gender earnings differentials in China and India. World Dev. https://doi.org/10.1016/j.worlddev.2017.04.016.
Levin, A., Lin, C.F., Chu, C.S.J., 2002. Unit root tests in panel data: asymptotic and finite-sample properties. J. Econom. 108 (1), 1–24. https://doi.org/10.1016/S0304-4076(01)00098-7.
Loayza, N., Fajnzylber, P., Calderon, C., 2005. Economic growth in Latin America and the Caribbean. Economic Growth in Latin America and the Caribbean. https://doi.org/10.1596/0-8213-6091-4.
Menegaki, A.N., 2019. The ARDL method in the energy-growth nexus field; best implementation strategies. Economies. https://doi.org/10.3390/economies7040105.
Menyah, K., Nazlioglu, S., Wolde-Rufael, Y., 2014. Financial development, trade openness and economic growth in African countries: new insights from a panel causality approach. Econ. Model. 37, 386–394. https://doi.org/10.1016/j.econmod.2013.11.044.
Mohmand, Y.T., Wang, A., Saeed, A., 2017. The impact of transportation infrastructure on economic growth: empirical evidence from Pakistan. Transp. Lett. Int. J. Transp. Res. 9 (2), 63–69. https://doi.org/10.1080/19427867.2016.1165463.
Pedroni, P., 1999. Critical values for cointegration tests in heterogeneous panels with multiple regressors. Oxf. Bull. Econ. Stat. 61 (s1), 653–670. https://doi.org/10.1111/1468-0084.61.s1.14.
Pesaran, M.H., 2004. General diagnostic tests for cross section dependence in panels. Iza

1240 (August), 1–42. https://doi.org/10.17863/CAM.5113.
Pesaran, M.H., Shin, Y., 2012. An autoregressive distributed-lag modelling approach to cointegration analysis. Econometrics and Economic Theory in the 20th Century 371–413. https://doi.org/10.1017/ccol521633230.011.
Pesaran, M.H., Pesaran, M.H., Shin, Y., Smith, R.P., 1999. Pooled mean group estimation of dynamic heterogeneous panels. J. Am. Stat. Assoc. 94 (446), 621–634. https://doi.org/10.1080/01621459.1999.10474156.
Pesaran, M.H., Shin, Y., Smith, R.J., 2001. Bounds testing approaches to the analysis of level relationships. J. Appl. Econom. 16 (3), 289–326. https://doi.org/10.1002/jae.616.
Phillips, P.C.B., Perron, P., 1988. Testing for a unit root in time series regression. Biometrika 75 (2), 335–346. https://doi.org/10.1093/biomet/75.2.335.
Rehman, F.U., Khan, M.A., Khan, M.A., Pervaiz, K., Liaqat, I., 2020. The causal, linear and nonlinear nexus between sectoral FDI and infrastructure in Pakistan: Using a new global infrastructure index. Res. Int. Bus. Finance 52. https://doi.org/10.1016/j.ribaf.2019.101129.
Röller, L.H., Waverman, L., 2001. Telecommunications infrastructure and economic development: a simultaneous approach. Am. Econ. Rev. 91 (4), 909–923. https://doi.org/10.1257/aer.91.4.909.
Romer, P.M., 1987. Crazy explanations for the productivity slowdown. NBER Macroecon. Annu. 2, 163–202. https://doi.org/10.1086/ma.2.4623715.
Sahoo, P., Dash, R.K., 2009. Infrastructure development and economic growth in India. J. Asia Pacific Econ. 14 (4), 351–365. https://doi.org/10.1080/13547860903169340.
Sahoo, P., Dash, R.K., 2012. Economic growth in South Asia: role of infrastructure. J. Int. Trade Econ. Dev. 21 (2), 217–252. https://doi.org/10.1080/09638191003596994.
World Bank, 1998. World development. World Dev. 26 (5). https://doi.org/10.1016/s0305-750x(98)90001-8. I.
Yu, N., de Jong, M., Storm, S., Mi, J., 2012. Transport infrastructure, spatial clusters and regional economic growth in China. Transp. Rev. 32, 3–28. https://doi.org/10.1080/01441647.2011.603104.