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MEASURING THE ROLE OF INFRASTRUCTURE QUALITY IN THE ECONOMIC GROWTH OF PAKISTAN

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ABSTRACT

The government's aim to accomplish social and economic development is realized through the optimal use of infrastructure. In this context, an infrastructure index is developed to investigate the role of infrastructure quality in Pakistan's economic growth from 1975 to 2018 particularly. The ARDL bounds testing cointegration with structural breaks confirm the presence of a long-run relationship amid the variables; economic growth, labour force, physical capital, and quality of infrastructure. Long-run findings indicate a positive and significant relationship between infrastructure quality and economic growth in Pakistan. From a policy standpoint, this analysis recommends that improvements in the existing infrastructure stock and utilizing the available resources efficiently would be extremely beneficial for Pakistan's economy.

Keywords: Output growth; Infrastructure quality index; Time series analysis; Principle component analysis; Pakistan.
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INTRODUCTION

In recent years, policymakers and academics have paid careful attention to the role of infrastructure in social welfare and economic progress. Both quantity and quality of infrastructure are considered major productivity stimulators (World Bank, 1994). A well-developed infrastructure may plunge a nation towards better, strong, and sustainable growth; thus, it enhances resilience in society. It helps to facilitate the provision of necessities through interlinking cities and towns and, thereby, connections with regional and international markets (Akyelken, 2015). The inadequacy of infrastructure impedes the speed of industrialization and economic development. Infrastructure is regarded as a prerequisite for obtaining higher levels of economic growth (Sawada, 2015). The limited and poor quality of infrastructure is the main constraint towards business growth (World Bank, 2015). Besides, an economy's ability to benefit from technological advancements depends on the physical infrastructure's availability, efficiency, and quality (Mitra et al., 2016). The global infrastructure investments have been $ 2.5 trillion (Global Infrastructure Outlook, 2017). In the coming years, the authorities expect much more infrastructure investments. Despite such colossal investments, the global demand and need for public infrastructure remain. It is a fact that the failure to provide a well-developed infrastructure can hinder economic development. According to World Bank (2017), the world's gross domestic product (GDP) per capita can rise by 2.6 % if the gap between actual and required infrastructure investment is narrowed. The gap can be bridged by developing a new approach to infrastructure that delivers long-term value to infrastructure investments. This necessitates the implementation of policies that make public investments more efficient (Global Infrastructure Outlook, 2017).

For many years, infrastructure and its allied concept remained out of the focus of economic literature. Adam Smith was the first to recognize the importance of infrastructure (especially transport infrastructure) in his growth vision. But unfortunately, less preference was given to infrastructure in the 19th and early 20th centuries. The developed countries, once developing countries, have heavily invested in infrastructure, especially in urban areas. But unfortunately, these countries could not attract the attention of macroeconomists. Rosenstein-Rodan (1961) suggested a major block of social overhead capital before building consumer goods. Nurkse (1953) was the first to define infrastructure as a collection of elements that provide production capacity services. In his opinion, these are large structures with expensive installations. Later, Hirschman (1958) defines infrastructure as a capital good providing a foundation for productive activities. Likewise, Fogel (1970) discussed the importance of railways to the inter-regional movement of agricultural products to highlight the role of railways in the economic prosperity of the United States of America. Aschauer (1989) is considered a pioneer who studied the practical importance of infrastructure. After that, many empirical studies investigated the significance of infrastructure in various socio-economic activities. Munnell (1992) supported his findings and found high output elasticity in this respect. Boopen (2006) investigated the positive influence of transportation infrastructure on Africa's GDP growth. Egert et al. (2009) assessed the effects of infrastructure on GDP growth in organizations for economic cooperation and development member countries (OECD). The findings revealed that infrastructure contributes to GDP growth in a good way. Similarly, numerous authors have suggested that infrastructure has a favourable impact on economic growth Asghar et al. (2011), Mishra et al. (2013), Sahoo and Dash (2012), and Sahoo et al. (2010). Likewise, Bashir and Faridi (2013) explored the impact of various dimensions of Pakistan's infrastructure. The findings revealed that telecommunications, roads, and education benefit economic growth; however, air travel and trains had little effect.

Infrastructure, according to many researchers Achour and Belloumi (2016), Ahmad (2016), Catudan (2016), and Hyun et al. (2017), has a significant impact on GDP growth. Most of the studies discussed infrastructure as a tool for development. However, few argued otherwise. The strand of these studies includes Al Nasser (2007), Chukwuemeka et al. (2013), Mohmand et al. (2017), Ogwo and Godswill (2017), Shi et al. (2017), and Soneta et al. (2012). Most of the studies mentioned above looked at the role of infrastructure stock in economic development, emphasizing the importance of efficient and better infrastructure utilization. In this respect, Hulten (1996) argued that those countries that utilize their resources efficiently achieve higher growth rates and vice versa. He developed an infrastructure-effectiveness index to measure the efficient utilization of infrastructure. Calderon and Serven (2004) investigated how infrastructure affects GDP growth and poverty. The authors found that the infrastructure quality considerably impacts economic growth. In the same way, Chakamera and Alagidede (2018) analyzed the relationship between economic growth and infrastructure quality. They suggested that poor-quality infrastructure may have significantly less impact on the growth process. Further, the authors found that poor quality of infrastructure reduces the actual benefits from the stock of infrastructure. The review of earlier studies (Ahmad, 2016; Aschauer, 1989; Calderon and Serven, 2004; Catudan, 2016; Munnell, 1992; Sahoo et al., 2010) suggested that infrastructure provides the foundation for sustained economic growth. In this connection, efficient and essential infrastructure endowments provide the best environment to flourish and progress. The introduction of new infrastructure does boost the growth process. However, poor quality infrastructure can dampen actual benefits out of infrastructure stock.

This study analyses the relationship between infrastructure quality and economic growth in a developing economy like Pakistan, given the importance of infrastructure in economic development. Why did we pick Pakistan as our case study country? Since infrastructure has been a policy priority for Pakistan in recent years. Pakistan has spent approximately $10 billion on infrastructure development and growth (Global Infrastructure Outlook, 2017). But still, infrastructure advantages did not reach the majority of the population. In 2019, about $1.5 billion were invested by the government in the energy sector (Hub, 2020). Regarding the energy sector, both the production and transmission sectors are inefficient. Resultantly, 18% of the total energy produced is lost in the transmission and distribution process, due to which Pakistan has faced a loss of Rs. 145 billion per annum in the last five years. To arrest the situation, Pakistan is still struggling with the energy crisis by adopting more reliable sources of energy production. These sources are less environmentally harmful and more cost-friendly (GOP, 2010). Further, more investments are being made in renewable sources of energy. Twelve wind projects are currently working in Pakistan, adding around 590 Mega Watts (MW) to the total energy. Likewise, eight projects are expected to be completed in 2021, adding 445 MW of power. Similarly, twenty-eight new wind projects with a production capacity of 1397.6 MW have been functional. Likewise, four solar projects with a production capacity of 400 MW are working in Pakistan (GOP, 2016). At the same time, 17 new solar power projects are also in the development process. For transportation, the road network handles around 96% of the traffic (GOP, 2010). The total road length is 263,942 kilometres (km). In Pakistan, 60% of the entire road network is in disrepair. The main reasons for such miserable conditions are bad maintenance, overloading of vehicles, inflated truck tyres, and shifting of freight and passengers from railways to roads (GOP, 2010).

Given the preceding context, the primary goal of this research is to advise policymakers and practitioners on potential contributions to improving the quality of infrastructure in Pakistan. To this end, this study considers various macroeconomic dimensions of infrastructure to investigate its impact on economic growth empirically. However, it adds to the current literature by expanding previous studies in several dimensions. First, this study considers the transport and power sectors that shape the infrastructure. We intend to add the communication data while constructing the infrastructure variable, but the data was not available on the quality of communication. Therefore, we restricted to use of transport and power variables to construct the infrastructure variable. This is the first study that examines the relationship between Pakistan's economic growth and infrastructure quality. Therefore, we decided to use the transport and power sector variables to represent Pakistan's infrastructure quality. Second, this study advises and attracts the attention of policymakers toward better quality and efficient utilization of infrastructure rather than merely enhancing the stock of infrastructure.

The remainder of the paper is structured as follows: The model, data, quality of infrastructure index construction, and estimation strategy are all described in Section 2. Section 3 discusses and explains the empirical results. The study is wrapped up in the final section, including policy recommendations for practitioners and policymakers.

METHODOLOGY

The Model

The majority of existing studies used the production function approach to analyze the effects of infrastructure on overall growth because they believe that said functional form is more suitable and stable (Barro and Sala-i-Martin, 1997; Mishra et al., 2013; Sahoo and Dash, 2012; Straub et al., 2008). Following the earlier studies, we investigate the relationship between GDP growth and infrastructure using an aggregate production function. By combining the quality of infrastructure index (QL) with labour and capital, the traditional aggregate production function is changed, as shown in Equation (1).

$$Y = f(L, K, QL) \tag{1}$$

Where Y represents output produced in the economy using the inputs of labour (L), physical capital (K), and quality of infrastructure (QL), the log-log model, as proposed by Calderon and Serven (2004) and Sahoo and Dash (2012), is utilized for the estimates, as shown in Equation (2).

$$\ln Y_t = \alpha_0 + \alpha_1 \ln L_t + \alpha_2 \ln K_t + \alpha_3 \ln QL_t + \varepsilon_t \tag{2}$$

Where $\ln$ it shows the natural logarithm, t represents the year, Yt is the real gross domestic product (GDP), Lt is labour force, Kt is the physical capital, and QLt is the quality of infrastructure. The parameters α_1, α_2 and α_3 are expected to have a positive sign.

Data and data sources

The data has been selected for 1975 to 2018.[1] The real GDP is chosen as a proxy of economic growth. The total labour force and real physical capital stock are used to represent the labour and capital, respectively.[2] For the quality of infrastructure, we used to transport and power variables. In this respect, Calderon and Serven (2004) developed an approach for creating an index that captures the influence of several infrastructure characteristics. We used the principal component analysis (PCA) technique for index construction.

Table 1. Description of variables and data sources.

Variables	Symbol	Variable Description	Sources
Economic growth	Yt	Gross domestic product(constant Prices 2006)	State Bank of Pakistan
Physical capital stock	Kt	The series is constructed using the perpetual inventory method.	State bank of Pakistan,
Labour force	Lt	Labour force (in million)	Pakistan Economic Survey
Quality of infrastructure index	QLt	Quality of infrastructure index variables	
	NDLt	Non-diesel locomotives	Pakistan Bureau of Statistics
	EARt	Energy from alternative resources (GW/h)	National Transmission and Dispatch Company, Pakistan
	PRt	Paved roads in kilometers	Pakistan Bureau of Statistics
	TDLt	Transmission and distribution losses of electricity (in %).	National Transmission and Dispatch Company, Pakistan

The index construction used four indicators representing transport and power sectors: paved roads, non-diesel locomotives, the energy produced from alternative energy resources, and transmission and

[1] The time period of the study is limited to the year 2018 due to data availability constraints.

[2] To determine the capital stock series ,we employed the perpetual inventory approach proposed by Rahman et al. Charfeddine (2021) ,with $K_t = (1 - \delta)K_{t-1} + I_t$. Following Burney and Syed (1986), the annual depreciation rate (δ) is set at 4% and $K_0 = I_t$ is set in the base year.

distribution losses. The information is derived from a variety of national and international data sources, including various issues of the Pakistan Economic Survey (PES), the World Development Indicators (WDI), the State Bank of Pakistan (SBP), the National Transmission and Dispatch Company (NTDC), and the Pakistan Bureau of Statistics (PBS). Table 1 summarises a complete description of variables as well as data sources.

Construction of quality of infrastructure index

The quality of the infrastructure index is constructed by using the PCA technique. PCA is a widely accepted data reduction technique. We used PCA because the correlation matrix of the indicators (shown in Table 2) reveals a high correlation between the variables. Further, a single variable cannot represent the quality of infrastructure; hence, we used the set of variables that best represents infrastructure quality. To achieve this, we used PCA to create a single variable that encompasses all infrastructure dimensions. Besides, two formal tests are used to check whether we may use the variable reduction technique like PCA or not. The Kaiser-Meyer-Olkin (KMO) test for sampling adequacy and the Bartlett test for sphericity are the two tests. The Bartlett test is used to determine whether or not the correlation matrix is an identity matrix.

Table 2. Correlation matrix of variables.

Variables	NDL_t	TDL_t	EAR_t	PR_t
NDL_t	1.000	0.512	-0.898	-0.962
TDL_t	0.512	1.000	-0.716	-0.589
EAR_t	-0.898	-0.716	1.000	0.956
PR_t	-0.962	-0.589	0.956	1.000

Note: Author's calculations.

The results of the KMO and Bartlett's tests, which were used to determine the suitability of data, are shown in Table 3. Because the KMO test value is larger than 0.6 and the probability value of the Bartlett test is also significant, both tests confirm that the variables are well-suited for the application of PCA approach.

Table 3. KMO and Bartlett test results for infrastructure quality index.

Test	Result
KMO Measure	0.706
Bartlett's Test	249.2666 (0.0000)
H0: variables are not intercorrelated	Reject

Note: These are the author's calculations. The p-value is shown in parenthesis.

After confirming that we may use PCA as a variable reduction technique, we proceed with PCA estimation.

Table 4. Principal component analysis of quality of infrastructure index.

Component	Eigenvalue	Proportion(%age)	Cumulative proportion(%age)
1	3.305	82.624	82.624
2	0.616	15.391	98.014
3	0.060	1.489	99.503
4	0.020	0.497	100.000

Note: Author's calculations.

The eigenvalues of the 1st principal component of the quality of infrastructure index account for 82% standardization variation, as shown in Table 4. Whereas the 2nd component explains a further 15% standardized variation, the remaining components only play a minor role in explaining the standardized variation. Hence, the 1st component is the more relevant measure of the quality of the infrastructure index. This component outperforms any other linear combination of explanatory variables in measuring the quality of the infrastructure index, so it is retained in the index formulation. The details of the four components extracted based on PCA are given in Table 5.

Table 5. Eigenvectors (Loadings).

Variable	PC_1	PC_2	PC_3
NDL_t	-0.510	-0.370	0.680
TDL_t	-0.390	0.880	0.220
EAR_t	0.540	0.020	0.680
PR_t	0.530	0.260	-0.130

Note: Author's calculations.

The values of 1st component have been retained and used as a weight in the construction of the infrastructure quality index. The respective weight has been multiplied by the corresponding value of the quality of infrastructure score to attain the index. To this end, the value of the 1st component has been plugged into Equation (3).

$$QL_t = -0.51NDL_t + 0.53PR_t - 0.39TDL_t + 0.53EAR_t \quad (3)$$

The subscript 't' refers to the year from 1975 to 2018.

After constructing the index, we have shown the relationship between GDP growth and infrastructure quality as a graphic representation. The association is given in Figure 1. The link reveals that, despite a rising trend between economic growth and infrastructure quality, Pakistan still spends a small amount on improving infrastructure quality.

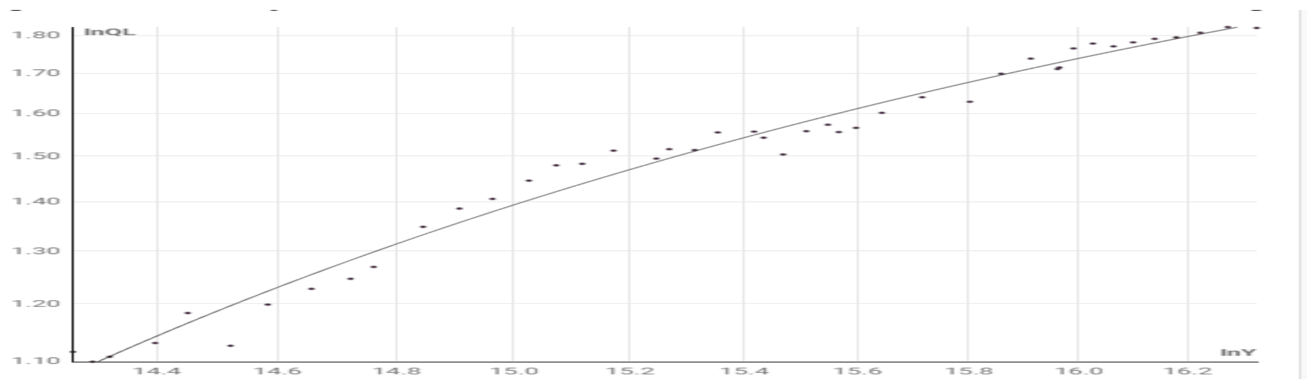

Figure 1. Pakistan's economic growth and infrastructure quality from 1975 to 2018.

Estimation Strategy

The estimation methodology is twofold. First, we determine the integration properties, and second to estimate elasticities, we use the Autoregressive Distributive Lag (ARDL) approach. For this purpose, two standard unit root tests are employed: the Phillips Perron (PP) test proposed by Phillips and Perron (1988) and the augmented Dickey-Fuller (ADF) test devised by Dickey and Fuller (1979). However, when the data contains structural breaks, ADF and PP unit root tests have low power. Since the time series may suffer many shocks (for example, fiscal crisis, policy changes, and structural changes). The traditional unit root tests do not capture these shocks and structural breaks. Although multiple unit root tests contain structural breaks, we focus on the unit root test by Lee and Strazicich (2003), which only allows for two breaks. The ARDL approach established by Pesaran et al. (2001) is used to detect cointegrating relationships among variables. This technique is preferred over other cointegration techniques because it produces reliable results with small sample sizes. It also provides short-run estimates along with long-run dynamics. We estimate Equation (4) by using ADRL.

$$\Delta \ln Y_t = \beta_0 + \sum_{i=1}^{n} \beta_1 \Delta \ln Y_{t-i} + \sum_{i=0}^{m} \beta_2 \Delta \ln L_{t-i} + \sum_{i=0}^{m} \beta_3 \Delta \ln K_{t-i} + \sum_{i=0}^{m} \beta_4 \Delta \ln QL_{t-i} + \delta_1 \ln Y_{t-1} + \delta_2 \ln L_{t-1} + \delta_3 \ln K_{t-1} + \delta_4 \ln QL_{t-1} + \delta_{D1} DUM_t + \delta_{D2} DUM_t + \varepsilon_t \quad (4)$$

The difference operator is shown by Δ, β_0 is the constant, $\beta_1 \to \beta_4$ are short-run coefficients, $\delta_1 \to \delta_4$ are long-run coefficients, t shows the time while n and m show optimal lags, which are determined using the Akaike information criterion (AIC) because of its superior explanatory power, and ε_t represents the residual term. The structural break dates[3] are represented by the dummy variable DUM_t. The ARDL technique has two steps. The combined significance of the lagged variables is first determined using the F-test. The null hypothesis of no cointegration ($H_0 = \delta_1 = \delta_2 = \delta_3 = \delta_4 = 0$) between economic growth, labour, capital, and quality of infrastructure index is tested against the alternative hypothesis ($H_1 = \delta_1 \neq \delta_2 \neq \delta_3 \neq \delta_4 \neq 0$). The computed F-value is compared to the critical bounds values generated by Pesaran et al. (2001). The null hypothesis is rejected if the computed F-value is greater than the upper bound value; otherwise, it is accepted. The decision for cointegration is uncertain if it lies between the value of the upper and lower critical bound. If a long-run relationship exists, the error correction model is represented by Equation (5).

$$\Delta \ln Y_t = \beta_0 + \sum_{i=1}^{n} \beta_1 \Delta \ln Y_{t-i} + \sum_{i=0}^{m} \beta_2 \Delta \ln L_{t-i} + \sum_{i=0}^{m} \beta_3 \Delta \ln K_{t-i} + \sum_{i=0}^{m} \beta_4 \Delta \ln QL_{t-i} + \delta_0 ECT_{t-1} + \varepsilon_t \quad (5)$$

The lagged error correction term is represented by ECM_{t-1}. The symbol δ_0 represents the ECM_{t-1} coefficient. The value of ECM_{t-1} term indicates the yearly rate of adjustment of variables in the long run. To check the model's goodness of fit, diagnostic tests such as serial correlation, non-normality, heteroscedasticity, and functional form are used. Short-run dynamics, according to Persan and Pesaran (1997), are critical in determining long-run parameter stability. Therefore, we investigate the CUSUM (cumulative sum) and CUSUMSQ (cumulative sum of squares) stability tests, which were recommended by the authors Brown, Durbin, and Evans (1975).

RESULTS AND DISCUSSIONS

The findings of descriptive statistics are presented in Table 6. Jarque- Bera (JB) test shows that economic growth, physical capital, labour, and quality of infrastructure index are normally distributed. The data is negatively skewed except for labour. The mean value of the quality of infrastructure index is the lowest, showing the poor quality of infrastructure in Pakistan compared to other factors, labour and capital. The Kurtosis found less than 3, confirming that the data has a lighter tail than a normal distribution.

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[3] The inclusion of dummy variables is based on Lee and Strazicich (2003) unit root test, which revealed two structural breaks in the dependent variable series.

Table 6. Descriptive statistics.

Description/Variable	lnY_t	lnL_t	lnK_t	$lnQL_t$
Mean	15.36353	3.623413	16.36206	1.512789
Maximum	16.32870	4.182050	17.16517	1.823147
Minimum	14.26320	3.027231	15.35254	1.099309
Std. Dev.	0.613996	0.345893	0.540183	0.225934
Kurtosis	1.901078	1.732062	1.860097	2.072231
Skewness	-0.217544	0.102684	-0.296371	-0.420002
Jarque-Bera	2.561039	3.024713	3.026322	2.871664
Probability	0.277893	0.220390	0.220213	0.237917

Before proceeding with the cointegration technique, the variables' stationary properties must be investigated. This is accomplished through the use of PP and ADF unit root tests. Table 7 shows that economic growth, labour, and infrastructure quality are the first difference stationary, I (1), whereas capital is level stationery, I (0). The structural breaks in the series are ignored by the ADF and PP tests. Therefore, with two structural breaks, Lee and Strazicich (2003) unit root test is used. The results (see, Table 8) show that economic growth and labour are the first difference stationary, that is, I (1), while capital and quality of infrastructure are level stationery, that is, I(0). Hence, the results confirm that our variables are I(0) or I(1) but not I. (2). These tests show that the dependent variable (economic growth) is I(1), which satisfies the prerequisite of Pesaran et al. (2001) to apply the ARDL bounds testing approach.

Table 7. Unit root tests results.

Variables	ADF			PP		
	At Level	First Difference	Decision	At Level	First Difference	Decision
lnY_t	-1.9970	-4.5049***	I(1)	-1.8953	-4.5214***	I(1)
lnL_t	-0.7684	-4.9927***	I(1)	-0.6919	-4.9618***	I(1)
lnK_t	-3.6813***	-	I(0)	-5.0946***	-	I(0)
$lnQL_t$	-1.6986	-7.6235***	I(1)	-1.3015	-7.7025***	I(1)

Note: *** shows 1% level of significance.

Table 8. Unit root test (Lee and Strazicich) with structural breaks results.

Variables	Crash Model						Decision
	At Level			First difference			
	LM-stat	Break 1	Break 2	LM-stat	Break 1	Break 2	
lnYt	-2.9918	2000	2008	-3.7716**	1985	1987	I(1)
lnLt	-2.8952	1995	2005	-5.7311***	1983	1995	I(1)
lnKt	-3.9388**	1999	2004	-3.6820**	1995	2013	I(0)
lnQLt	-4.0135**	1994	2007	-3.5833**	1990	2005	I(0)

Note: *** and ** represent the 1% and 5% significance levels, respectively.

After accessing the unit root properties, we estimate VAR lag length criteria for optimal lag order decision, and hence, AIC is selected. In Table 9, AIC recommends lag 2 as the optimal lag order.

Table 9. The lag order selection.

Lag	HQ	AIC	FPE	LogL	SC	LR
0	-9.483485	-9.544361	8.42e-10	199.6594	-9.377184	NA
1	-23.63181	-23.93619	4.75e-16	510.6919	-23.10030*	546.2034
2	-23.77279*	-24.32068*	3.31e-16*	534.5739	-22.81608	37.27927*
3	-23.24082	-24.03222	4.70e-16	544.6606	-21.85891	13.77693

*represents the criterion's choice of lag order, each test at 5% level, Sequential modified (LR) test statistic, Hannan-Quinn information criterion (HQ), Akaike information criterion (AIC), Final prediction error (FPE), Schwarz information criterion (SC).

The ARDL approach with structural breaks is used, as described by Rafindadi and Ozturk (2016). Table 10 displays ARDL cointegration test results; when economic growth is used as a regressand, the computed F-value is greater than the lower and upper bound critical values. From 1975 to 2018, this research supports the existence of a stable long-run relationship between the variables.

Table 10. ARDL bounds testing cointegration results.

Model	Optimal Lags	F-Statistic	Break Years	Cointegration
$lnY_t=f\ (lnL_t,lnK_t,lnQL_t)$	(2, 2, 2, 1)	10.1763***	2000, 2008	Exist
Significant Level	Critical Values			
	I(0)		I(1)	
1%	4.983		6.423	
5%	3.535		4.733	
10%	2.893		3.983	

Note: *** represents a 1% level of significance.

Table 11. Long-run and short-run results.

Variables	Coefficient	t-statistic	Prob.value
Long-run analysis			
Constant	0.0051	0.3658	0.7172
lnLt	0.5960***	7.2916	0.0000
lnKt	0.7902***	17.4245	0.0000
lnQLt	0.1463**	2.4457	0.0208
D_{2000}	-0.0432***	-3.7663	0.0008
D_{2008}	-0.0328**	-2.1844	0.0372
Short-run analysis			
ΔlnY_{t-1}	0.2930***	2.5708	0.0155
ΔlnL_t	-0.0488	-0.4558	0.6519
ΔlnL_{t-1}	-0.2165	-1.5158	0.1404
ΔlnK_t	3.4777***	7.3077	0.0000
ΔlnK_{t-1}	-0.7485	-1.4496	0.1579
$\Delta lnQL_t$	0.0493	0.8451	0.4049
ECM_{t-1}	-0.9879***	-6.7019	0.0000
R^2	0.7651	Adj.R^2	0.6991
F-statistic	11.5857***	-	-

Note: ***, ** and * represent 1%, 5% and 10% of significance levels, respectively.

Following confirmation of cointegration, the AIC criterion is considered to determine the regressors' long- and short-run coefficients. In Table 11, the labour and capital coefficients are 0.5960 and 0.7902, respectively, showing that economic growth is increased by 0.60 % and 0.79 % if the labour and capital are increased by 1%, ceteris paribus. Infrastructure quality has a favourable and considerable impact on GDP growth. Its coefficient shows that a 1% increase in infrastructure quality boosts GDP growth by 0.15 %, ceteris paribus. This infers that improving the quality of infrastructure leads to increase GDP growth in Pakistan. These findings are in line with those of Calderon and Serven (2004) and Hulten (1996). The dummy variables for the structural break in 2000 and 2008 had a negative and significant impact on Pakistan's economic growth. The negative and significant effect could be owing to the fact that the year 2000 was marked by a severe drought, which resulted in a bad harvest in 2001, resulting in a drop in agricultural production, dragging real GDP growth down while the global financial crisis of 2008 was linked to the year 2008. The coefficient of the dummy variable 2008 confirms that the 2008 global financial crisis harmed the Pakistani economy. Table 11 displays the ARDL approach's short-run estimates. The findings suggest that economic growth and infrastructure quality have a positive but statistically insignificant relationship. The capital coefficient is also significant and positive. The ECM_{t-1} coefficient is 0.9879, which is negative and statistically significant, implying that 99 % of short-run divergences are adjusted every year in the long run.

The results of the diagnostic tests are shown in Table 12. The LM test has a probability value greater than 5%, indicating that serial correlation is not a problem. The Breusch-Pagan Godfrey test is employed to see if the residuals are heteroscedastic, and the test inferences demonstrate that they are not. The residuals are normally distributed because the probability value of the Jarque-Bera test is greater than the 5% level. The Ramsey RESET test ensures that the model's functional form is correctly defined. Diagnostic test results confirm that the model is the best fit.

Table 12. Diagnostic test results.

Test	Serial correlation	Normality	Heteroscedasticity	Ramsey RESET
F statistic	0.2949	2.7347	0.9842	0.1021
P value	0.1626	0.2547	0.4859	0.7516

To ensure parameter stability, the CUSUM and CUSUMSQ tests are used, and their plots are shown in Figures 2 and 3. The residuals of CUSUM and CUSUMSQ remain within the critical boundaries of a 5% level of significance, which implies the stability of the model.

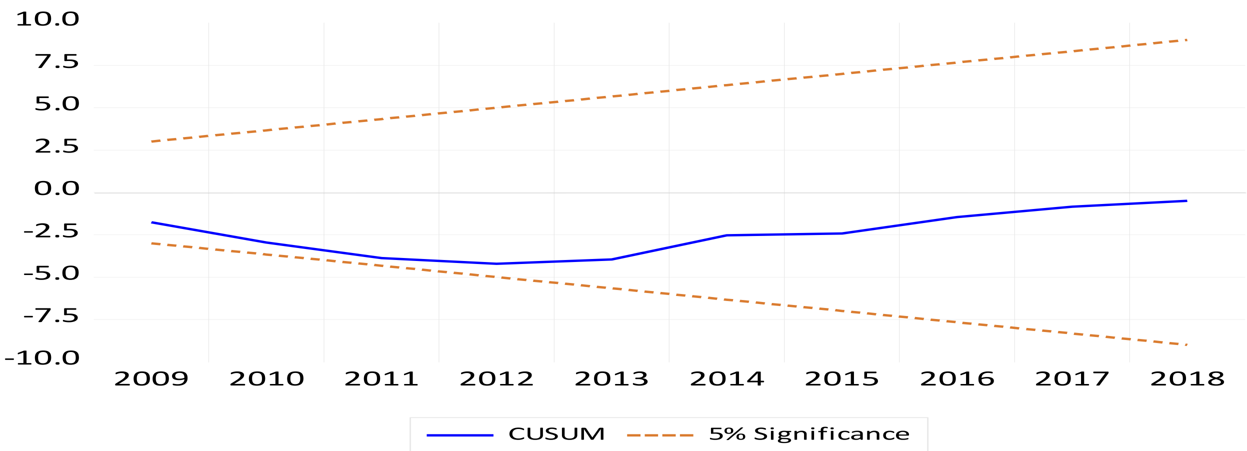

Figure 2. Plot of CUSUM.

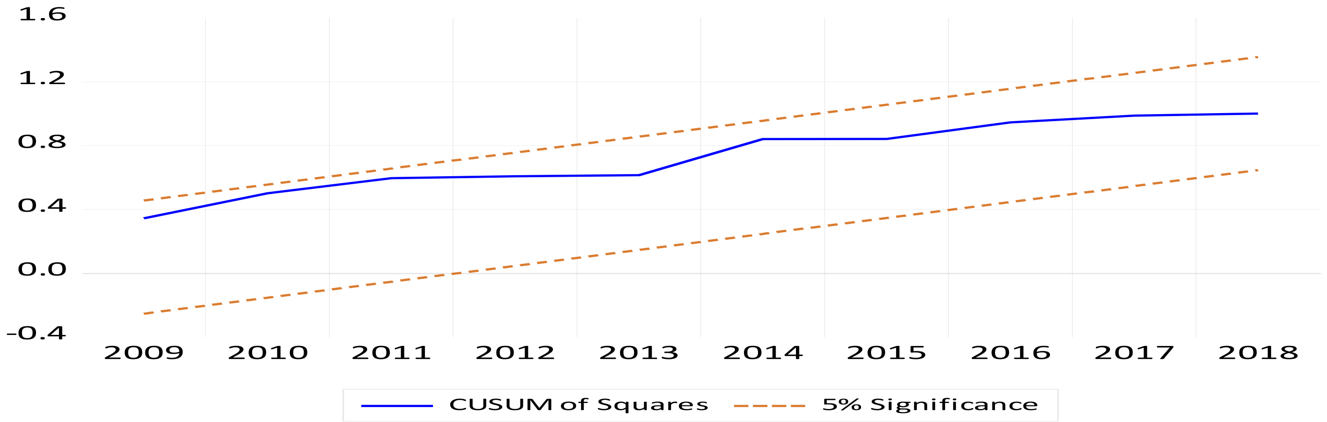

Figure 3. Plot of CUSUM Square.

CONCLUSION AND POLICY IMPLICATIONS

Infrastructure is considered an important tool in the development of a country, especially for developing countries like Pakistan. The impact of public investment is determined not only by the amount invested but also by the efficiency with which it is put to use. This study explained that infrastructure has various dimensions that better explain GDP growth. The study constructed the quality of infrastructure index using the PCA technique. The ARDL approach with structural breaks is used to verify the presence of a cointegrating relationship between the variables. The long-run relationship between economic growth and infrastructure quality in Pakistan is positive. Based on the findings of this study, we propose some policy implications for policymakers. Government and policymakers may focus on the quality of infrastructure and services through maintenance and upgrading transportation and power generation systems.

The road investment is mainly funded from the annual budget allocation, and these allocations have historically been found insufficient for a timely and necessary road capacity expansion. This leads to poor road network quality in Pakistan. Most of the new projects are initiated for political gains. Roads are frequently purposefully left weak and prone to rapid deterioration, so contracts can be awarded repeatedly. Besides, there seems to be fungibility of expenditures related to infrastructure. To correct the situation, the bureaucratic role requires major revamping so that the allocated budget may be used better to expand infrastructure quality in Pakistan. There is a need to focus on the quality of the existing road besides investing in new projects. In addition, Pakistan has a significant potential for renewable energy sources such as biomass, hydropower, solar, and wind. The appropriate development and application of these alternative energy technologies could benefit the country. These benefits may be in terms of energy, economy, and environment. Lastly, the generation of energy by installing the new program is not enough rather; the focus should be diverted toward the better distribution of energy. Because the reduction in the power and distribution losses helps the country meet its increasing energy demand and costs much less. These measures will improve infrastructure quality, resulting in improved transportation and power for residents and the industrial sector. With better quality, the industrial sector will grow, enhancing the economic growth in Pakistan. Further, with improvements in the infrastructure, the Government of Pakistan may get more benefits from the China-Pakistan Economic Corridor (CPEC) project. This infrastructure expansion would also increase Pakistan's interconnections with the rest of the globe, which will help the country's economic growth.

We propose that future studies include the governance variable to assess the impact of institutional quality on GDP growth and infrastructure. Besides, the threshold level at which the infrastructure contributes to economic growth can be determined. The study's limitations are related to data constraints for which data collection agencies should concentrate so that with big data, better analysis can be conducted.

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