Impact of Infrastructure on Economic Growth: A Comparative Analysis of Developed and Developing Countries

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Abstract

The significance of infrastructure for economic growth and the welfare of a country has become a burning issue for the last three decades. This research examines the impact of infrastructure on economic growth across selected developed and developing countries. The dependent variable is economic growth, measured by the growth rate of gross domestic product, and the independent variables to measure infrastructure are transportation, communication, education, and electricity. The data set for analysis is collected from online sources of World Development Indicators for eighteen years (2000-2018). The panel data set of this study is evaluated by constructing fixed and random effects models. The findings reveal that infrastructure plays a significant role in the economic growth of developing countries, with less contribution in the case of developed countries. Because the infrastructure of developed countries is already well established, and if they invest more in infrastructure, the economic growth will rise slightly. So, they invest more in innovations and technology rather than in infrastructure. In developing countries, transportation, communication, and electricity have a positive impact, but education is insignificant in the growth rate. This study's findings align with the Solow Growth Theory, which states that public capital, in which infrastructure is included as necessary input in the production process, contributes to economic growth.

Keywords: Infrastructure; Economic Growth; Developed and Developing Countries; Solow Growth Theory.

Introduction

The link between economic development and efficient infrastructure provision is globally viewed in research and academic circles (Calderon & Serven, 2008). The empirical estimation of this linkage is complex to determine (Sahoo & Dash, 2009). The evidence reveals that there exists a wide gap in infrastructure development between developed and developing countries (Abiad et al., 2018; Kodongo, 2016; Ahmad et al., 2013).

The recent research on infrastructure and economic growth is needed because developing countries must meet the sustainable development goals (SDGs) (Abbas & Choudhury, 2013; Alinsato, 2015). The significant challenges recently developing countries are facing for better development. Firstly, the absence of economic resilience and the inability need help to fill the technology gap. Secondly, there is insufficient production of basic needs, which, as a result, contributes to inequality and regional disparities within the country and among the countries.

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Spending on infrastructure has gained much attention internationally. *Infrastructure* is a long-living system that is capital-intensive and facilitates the people. The public sector of an economy usually provides it, and infrastructure expenditures are mainly concerned with the expenditure on roads, highways, railroads, electricity, education, health, and water. Infrastructure is not only necessary for economic activities made by the government but also for the economy's private sector. At the same time, households and businesses can be facilitated by infrastructure (Stupak, 2017). Infrastructure accumulates capital stock and, as a result, will directly impact productivity. Labor productivity can be increased by improving telecommunication, technology, education, and health facilities.

In addition, it affects the demand side by providing people with those required services such as clean water, power for heat, cooking, and light, communication sources, and transportation. The absence of some basic infrastructure will lead to poverty in any economy; there is no doubt that increasing capital stock through infrastructure improvement is only a way for economic growth and poverty reduction. If a developing country wants to break the circle of poverty, then there must be sustained economic growth. Many countries are applying fiscal tools such as taxation and government spending through fiscal policies to achieve long-term economic growth with maximum economic welfare. A large number of scholars in support of enhancing public expenditure will stimulate the circulation of money in an economy, leading to an increase in foreign direct investment, which will create employment opportunities.

According to Ansar (2016), China is one of the rapidly growing countries of this decade, with one-fifth of the total population in the world. China's economic growth increased from 7.5% to 10% in 1970-1999, and in 2008, it maintained a sustained increase in capital formation. The transportation and business sector has improved with the continuous growth in public expenditure on infrastructure in China. Moreover, the country spends 8.5% of GDP on construction.

According to Nurkse (1971), balance growth is a better foundation for foreign trade. He focused on explaining the importance of improving the facility's transportation system. Also, he advocated reducing transport costs, reducing tariff barriers, and creating a customs union to increase economic growth in a country. Thirwall (1995) explained from the supply side that improved infrastructure resulted in a reduction of cost and an increase in the production of the agriculture sector just because individuals can easily access markets. Furthermore, poor African farmers and customers are cut off from the markets due to the need for more infrastructure facilities.

Infrastructure can be divided into social and physical infrastructure (transportation, energy resources, telecommunication, and essential utilities) in the early stages of following economic growth policies. Physical infrastructure is needed to support society and the economy. In the long run, changes in the transportation system could enhance an economy's manufacturing capacity by increasing productive output and improving profitability (Sojoodi, 2012).

A large number of researchers have evaluated the connection between infrastructure and development. However, Pakistan still needs to explore this issue thoroughly. The factors behind this are the complexities of evaluating public sector infrastructure, investigating its association with development, and the impact of policies.

Spending on infrastructure such as electric power, water, transportation, and technological developments spur economic growth and contribute to poverty alleviation and improved living standards in developing economies. Infrastructure-to-economic growth is challenging, while infrastructure investment is essential for manufacturing recovery and economic expansion (Babatunde et al., 2012).

This research aims to identify the impact of infrastructure on economic growth by considering the sample size of ten developed and ten developing countries from 2000 to 2018.

This study is organized into six sections. The second section reviews past studies on infrastructure and economic growth. The theoretical framework is provided in section three. Section four explains the model with variable construction, data with sources, and methods for empirical testing and findings. Section five provides the research findings, and section six concludes the study and suggests recommendations.

Literature Review

Several reviews on the link between infrastructure and economic growth are available. Javid (2019) examined the fact that formal and informal infrastructure investment has beneficial but distinct impacts on economic development. Significant and positive influence on developing individuals is explained in studies. Chakamera and Alagidede (2018) showed significant, positive downward pressure on SSA growth between the quantified infrastructure elements. Another study showed scientific evidence that port infrastructure reliability and logistics efficiency have significant economic and environmental effects (Munim & Schramm, 2018). Gurara et al. (2018) conducted a broad set of actions to improve public spending efficiency, domestic development, and private investment. Using infrastructural investment, Omojolaibi and Ogbeifun (2017) examined the enormous positive impact on agricultural production. Bakar and Mat (2017) explained the beneficial and positive effects on the four countries' economic development. A positive significant impact on entrepreneurial growth in Brazil is examined by Uchehara (2016). Growth can improve citizens' well-being and ensure economic development in Nigeria and Malaysia (Onyimadu, 2015). Pradhan et al. (2014) studied the fact that the advancement of infrastructure causes economic expansion and that the source can be unidirectional. The long-term effect on economic development of private investment and national infrastructure investment is favorable and vital. Communication infrastructure significantly impacts Pakistan's economic prosperity. Olaseni and Alade (2012) explained that infrastructure is strongly linked to economic growth. Transportation infrastructure plays a significant role in Pakistan's rising economic growth. Meaningful consideration of the connection between infrastructure and economic development is studied through the socioeconomic impact of infrastructure investments (Snieška & Šimkūnaitė, 2009). Transportation services, including fixed-line telecommunications infrastructure, have a favorable and positive effect using autoregressive distributed lag (Sojoodi et al., 2012). Infrastructure has a beneficial or substantial effect on developing Asia's per capita economic growth level (Straub & Terada, 2010).

Pedroni and Canning (1999) analyzed the results of the provision of infrastructure services in the long run on the per capita income of a panel of countries. The results of this study showed that results were contrasting across the countries. On average, telecommunication and paved roads were promoting growth. Besides, telecommunication and roads were undersupplied in most countries while oversupplied in other countries, whereas on average, the provision of infrastructure was growth contributing while electricity generation was under-supplied. Brenneman and Kerf (2002) found a positive effect of infrastructure availability on education, especially for transportation and energy services and on health-related issues, particularly sanitation, safe drinking water, power, and transport sector, and less for telecommunication based on highly extensive and broad survey obtained.

Theoretical Framework

Solow Growth Model was established by Nobel Prize-winning economist Robert Solow, who extended the Keynesian and Harrod-Domar models. The Solow model seems most relevant to the current economic growth concept. Most of the research that is based on macro studies on the impact of infrastructure take their point of origin in Solow (1956), who encouraged production functions such as:

$$Y = f(A, K, L) \quad (1)$$

Where Y is aggregated production (GDP), K is capital, L is labor and A is factor of productivity. A common assumption is that (i) is Cobb-Douglas function so that:

$$Y = A.K^{\alpha}.L^{\beta} \quad (2)$$

There are various means of presenting infrastructure in the production function, the foremost common being to further specify capital (K) into various parts of capital, e.g.

$$Y = A.(K_{Private})\alpha^{1}.(K_{Public})\alpha^{2}.L^{\beta} \quad (3)$$

In this case the government capital (in which infrastructure is a part) is seen as essential input in the process of production. This approach was adopted by Aschauer (1989) and government capital (K_{Public}) is at that point expected to have a direct impact on the level of production with an elasticity of α2. Public capital can be further separated into various sorts of public capital, e.g. various sorts of infrastructure. Aschauer (1989) separates public capital into military capital, main infrastructure (airports, highways, mass transit, gas facilities, water facilities, sewers) and other non-military capital.

Keynesian theory illustrates that when government increase investment it leads to surpassing growth rate of the economy. However, it has been argued that government intervention helps to raise failure that might arise from the inabilities of the market. According to the accelerator effect, the planned capital investment is linked positively to the past and expected growth of national income. Keynesians favor labor-intensive projects e.g. transport infrastructure and new housing.

Data Sources and Methodology

A mathematical model is developed to evaluate the impact of infrastructure on the growth rate: A comparative analysis of developed and developing countries.

$$Economic\ Growth = f(infrastructure)$$

Model 1

$$GDPG_{it} = \beta + \beta_1 TRANS_{it} + \beta_2 COMM_{it} + \beta_3 EDU_{it} + \beta_4 ELEC_{it} + \beta_5 X_{it} + \mu_{it} \quad (4)$$

Model 2

$$GDPG_{it} = \beta + \beta_1 TRANS_{it} + \beta_2 COMM_{it} + \beta_3 EDU_{it} + \beta_4 ELEC_{it} + \beta_5 X_{it} + \mu_{it} \quad (5)$$

Model 1 is constructed for developed countries and model 2 is for developing countries. Equation (i) and (ii) developed the model, show that dependent variable is growth rate of gross domestic product (GDPG) and explanatory variables are transportation (TRANS), communication (COMM), education (EDU) and electricity (ELEC) and a set of control variables(X) are population (POP), per capita income (PC), employment (EMP) and technology (TECH). μ is random or stochastic error term with the properties of zero mean and non-serial correlation. Subscript i represents for countries and t for time period.

In order to analyze the models the secondary data from 2000 to 2018 is collected and panel data techniques are applied. Data is taken from World Development Index (WDI). The descriptive analysis of the study variables are provided in appendix B1 and appendix B2. Furthermore, the correlation coefficients are also given in appendix B3 and B4. The correlation analysis involves no dependence or causality of the variables but refers to the type and degree of association between two variables. The coefficients of correlation reveal that there is positive as well as negative association among variables.

Methodology

Panel data technique is applied to estimate the equations 4 and equation 5. Cross-sectional and time series data are combined in panel data set.

Fixed Effect Model

Fixed effect model considers the same slopes along with constant variance across groups and investigated group variations in intercepts. The least squares dummy variable (LSDV), between effect and within effect estimation techniques use in fixed effects models. Thus, ordinary least squares (OLS) regressions with dummies, absolutely, are fixed effect models. The fixed effect model with functional forms is given in equation (6);

$$GDPG_{it} = (\gamma + \mu_i) + \gamma_1 TRANS_{it} + \gamma_2 COMM_{it} + \gamma_3 EDU_{it} + \gamma_4 ELEC_{it} + \gamma_5 X_{it} + v_{it} \quad (6)$$

Where v_i is independently identically distributed and represents fixed effect with distinct to individual or time spam that is not included in the regression. And γ is used for developed and developing countries.

Random Effect Model

The random effect model is based on the assumption that individual effect is not correlated with any regressor and estimates variance of error terms specific to groups or times. The functional form of random effect model is given in equation (7);

$$GDPG_{it} = \sigma + \sigma_1 TRANS_{it} + \sigma_2 COMM_{it} + \sigma_3 EDU_{it} + \sigma_4 ELEC_{it} + \sigma_5 X_{it} + \epsilon_{it} \quad (7)$$

σ represents the developed and developing countries. Thus, equation (2) is heterogeneous and an individual specific random error or a composite error term.

Hausman Test

Hausman test is basically used to distinguish between the fixed effect and random effect model. Random effect model is also preferred to fixed effect model because it is more appropriate than fixed effect model.

Empirical Findings and Discussions

The unit root test is essential for testing the stationary for all variables, and the consequences of the Im Pesaran and Shin (IPS) test are more valuable than others. Panel unit root test with trend and intercept is applied on all models (5) and (6), at levels and first differences under Schwartz information criterion for lag length—table 1 and 2 show that all variables are stationary at level.

Table 1 shows the random effect results of developed countries. By the random effect model, as the probability value of transportation is more significant than 0.05 percent, it has an insignificant impact on the GDPG in the case of developed countries. The coefficient value of transportation is 0.055, so if investment in transportation increases by 1 percent, it will raise the GDPG by 0.055 units. The probability value of communication is 0.000, which means that it significantly and positively impacts GDPG. The coefficient value of communication is 1.013 percent, which means that if investment in this kind of infrastructure increases by 1 percent, the GDPG will raise 1.013 units. The probability value of education is more significant than 0.05, which means that it has an insignificant and negative impact on the GDP of developed countries. The coefficient value of education is 8.271, which means that if the enrollment rate in secondary schools increases by 1 percent, it increases the growth rate of gross domestic product by 8.271 units. The probability value of electricity is 0.03, which is less than 0.05, which means that it significantly impacts GDPG. The coefficient value of electricity is -1.322, which means that if electricity generation increases by 1 unit, the GDPG will decrease by -1.322 percent. Control variables like per capita income and technology have a positive and highly significant impact on GDPG. While employment, which is the other control variable, has a positive effect on the growth rate but is insignificant. On the other side, population negatively affects developed countries' growth rate but is highly significant.

Table 2 shows the random effect results of ten selected developing countries. By the random effect model, as the probability value of transportation is less than 0.05 percent, it has a highly significant impact on the GDPG in the case of developing countries. The coefficient value of transportation is 0.016, so if investment in transportation increases by 1 percent, it will raise the GDPG by 0.016 units. Transport infrastructure significantly increases GDP growth. The probability value of communication is 0.000, meaning it significantly and positively impacts GDPG. The coefficient value of communication is 0.406 percent, which means that if investment in this infrastructure increases by 1 percent, the GDPG will raise 0.406 units. The communication indicator is also significant at the 5 and 10 percent significance level. The probability value of education is less than 0.05, meaning that it significantly impacts the GDP of developing countries. The coefficient value of education is 3.50, which means that if the enrollment rate in secondary schools increases by 1 percent, it increases the growth rate of gross domestic product by 3.50 units. The probability value of electricity is more significant than 0.05, meaning it has an insignificant impact on GDPG. The coefficient value of electricity is 0.031, which means that if electricity generation increases by 1 unit, then the growth rate of gross domestic product will increase by 0.031 percent. The control variables, per capita income and technology, positively impact GDPG and are highly significant. Employment has a negative and insignificant impact on the growth rate. Population has a positive effect on the growth of developing countries, but it is highly insignificant. Investment in economic infrastructure has been higher than in social infrastructure, positively impacting economic growth.

Table-1 Random effect model of developed countries

Dependent Variable: GDPG						
Model Specif	1	2	3	4	5	6
TRANS	0.055	0.152	1.617	0.939	0.094	-0.004
	(1.141)	(1.254)	(1.178)	(1.179)	(1.099)	(1.104)
	[0.049]	[0.121]	[1.372]	[0.797]	[0.085]	[-0.004]
LCOMM	1.013	0.996	0.912	0.930	1.003	1.057
	(0.148)	(0.145)	(0.148)	(0.152)	(0.139)	(0.112)
	[6.846]**	[6.885]**	[6.179]**	[6.126]**	[7.195]**	[9.463]**
LEDU	8.271	4.332	2.433	2.461	1.077	0.981
	(1.935)	(1.283)	(1.097)	(1.572)	(0.014)	(1.533)
	[0.431]	[1.924]*	[0.479]	[1.041]	[1.427]	[-2.772]**
ELEC	-1.322	-0.819	-1.340	-1.301	-0.741	1.658
	(0.605)	(0.585)	(0.594)	(0.609)	(0.575)	(0.448)
	[-2.184]**	[-1.401]	[-2.255]**	[-2.137]**	[-1.289]	[3.702]**
EMP		0.067				0.062
		(0.069)				(0.058)
		[0.971]				[1.076]
PC			0.012			0.006
			(0.003)			(0.003)
			[3.637]**			[2.238]**
POP				-0.022		-0.022
				(0.009)		(0.008)
				[-2.323]**		[-2.665]**
TECH					0.278	0.321
					(0.063)	(0.051)
					[4.418]**	[6.280]**
Observations	190	190	190	190	190	190
R-squared	0.263	0.251	0.316	0.289	0.317	0.407
Cross Sectional Units	10	10	10	10	10	10

Dependent variables is GDPG
St. Error is in ( )
t-statistics is in [ ]
*** represents significance at 5%. Source: Author's Calculation based of EViews 9.5*

Table 2: Random effect model of developing countries

Dependent Variable: GDPG

Model Specification	1	2	3	4	5	6
TRANS	0.016 (0.002) [7.944]**	0.016 (0.002) [7.943]**	0.002 (0.003) [0.604]	0.015 (0.001) [7.708]**	0.015 (0.002) [9.287]**	0.0002 (0.003) [0.074]
LCOMM	0.401 (0.084) [4.759]**	0.406 (0.085) [4.799]**	0.391 (0.080) [4.870]**	0.425 (0.079) [5.325]**	0.418 (0.068) [6.188]**	0.370 (0.064) [5.781]**
LEDU	3.501 (1.407) [2.50 2]**	4.006 (1.744) [1.553]	0.741 (0.155) [0.405]**	1.050 (0.096) [1.066]	3.011 (1.655) [1.347]	0.049 (0.006) [0.015]
ELEC	0.031 (0.063) [0.492]	0.033 (0.063) [0.519]	0.117 (0.063) [1.857]*	0.006 (0.060) [0.106]	0.035 (0.051) [0.676]	0.189 (0.050) [3.788]**
EMP		-0.0002 (0.0002) [-0.821]				-0.0003 (0.0002) [-1.914]*
PC			0.001 (0.0002) [4.081]**			0.001 (0.0002) [5.761]**
POP				0.006 (0.005) [1.085]		-0.013 (0.006) [-2.225]**
TECH					0.017 (0.003) [6.906]**	0.028 (0.003) [9.732]**
Observations	190	190	190	190	190	190
R-squared	0.256	0.256	0.320	0.222	0.315	0.551
Cross Sectional Units	10	10	10	10	10	10

Dependent variables is GDPG
St. Error is in ( )
*t-statistics is in [ ] ,** represents significance at 5% and * represents significance at 10%.*

In developed and developing countries, investment in transportation and communication positively affects economic growth. However, the share of communication is much higher in the growth rate of developed countries than in developing countries. In developing countries, secondary school education is highly significant for growth rate. However, the ratio of students could be higher in schools, which is why it has a negative impact on economic growth. Developed countries have already invested in social infrastructure (secondary education), contributing to growth. Electricity also has a positive effect on the economic growth of developing countries, while for developed countries, it is a highly significant but negative impact.

Conclusion and Recommendations

This research investigates the contribution of infrastructure to the economic growth of selected developed and developing countries. The random effect technique is applied to estimate the study models. The literature revealed various positive and negative findings regarding the effects of infrastructure on economic growth. This study's results show that infrastructure, such as transportation and communication, positively impacts economic growth, while education and electricity negatively affect growth rates. In developing countries, transportation, communication, and electricity positively impact economic growth, but education has a negative impact while it shows significant results. Per capita income and technology positively affect the growth rate of developing and developed countries. The population has a positive impact on the economy of developing countries and vice versa in the case of developed countries. The capacity of businesses to produce goods and services more efficiently is an essential part of economic growth and boosts infrastructure investment if well targeted and, depending on the degree of crowding out, likely contributes to increased productivity over time, leading to higher GDP over the long term.

Further, public infrastructure investments may affect employment in the near and medium term. Economic research suggests that deficit-financed investments would achieve the most significant impact on short- and medium-term employment during a recession. In the long term, infrastructure investment is less likely to impact employment outcomes significantly. The long-term results of both sectors show that infrastructure investment in developing countries is more effective in economic growth than in developed countries. In developing countries, infrastructure significantly and positively affects the growth rate. Developing countries should take some steps to adopt advanced technology because technology plays a vital role in the economy. Developing countries should improve and maintain the education system for bare knowledge and skills.

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Appendix-A

Sample of developed countries

Serial. No	**Developed countries**	**Developing countries**
1	China	Bhutan
2	Hong Kong	Egypt
3	Ireland	Eritrea
4	Iceland	Pakistan
5	Norway	Romania
6	Netherlands	Thailand
7	Poland	Uganda
8	Spain	Ukraine
9	United Kingdom	Zambia
10	United States	Zimbabwe

Appendix-B

B-1 Descriptive Statistics of Developed Countries

Variables	Mean	Min	Max	Std. Dev.
GDPG	2.59	5.74	2.46	4.87
TRANS	0.13	0.02	0.24	0.06
COMM	1285.68	30.72	19578.50	1702.87
EDU	625.97	5.82	5682.92	921.57
ELEC	0.18	0.003	0.69	0.13
Control Variables				
EMP	0.87	0.02	4.26	0.96
PC	13.46	19.14	87.87	19.10
POP	24.14	6.76	39.76	5.94
TECH	0.74	0.003	7.34	1.07

Source: Author's calculations

B-2 Descriptive statistics of developing countries

Variables	Mean	Min	Max	Std. Dev.
GDPG	2.36	8.43	8.56	2.43
TRANS	13.30	0.05	113.06	21.37
COMM	1199.78	5.19	6865.89	1310.07
EDU	394.90	1.75	2010.36	384.65
ELEC	0.80	0.00	4.02	0.71
Control Variables				
EMP	135.95	8.43	1908.85	215.80
PC	175.52	0.05	1659.73	329.27
POP	5.47	5.19	35.22	9.98
TECH	5.24	1.75	71.61	13.79

Source: Author's calculations

B-3 Correlation matrix of developed countries

	GDPG	TRANS	COMM	EDU	ELEC	EMP	PC	POP	TECH
GDPG	1								
TRANS	0.05	1							
COMM	0.019	0.13	1						
EDU	-0.08	0.25	0.02	1					
ELEC	0.05	0.51	-0.04	0.37	1				
EMP	0.13	-0.29	0.15	0.15	-0.09	1			
PC	0.18	-0.43	-0.11	-0.14	-0.25	0.12	1		
POP	-0.28	0.32	0.15	0.22	0.31	-0.08	-0.23	1	
TECH	0.19	-0.19	-0.12	-0.13	0.06	0.35	0.21	-0.02	1

Source: Authors' calculation

B-4 Correlation matrix of developing countries

	GDPG	TRANS	COMM	EDU	ELEC	EMP	PC	POP	TECH
GDPG	1								
TRANS	0.09	1							
COMM	0.29	-0.18	1						
EDU	-0.19	-0.12	0.09	1					
ELEC	-0.31	-0.05	-0.27	0.32	1				
EMP	-0.11	0.19	0.06	0.32	0.03	1			
PC	0.02	0.88	-0.15	-0.08	-0.17	0.24	1		
POP	-0.32	-0.32	-0.15	0.15	0.29	-0.34	-0.27	1	
TECH	-0.12	-0.11	-0.06	-0.19	0.07	0.05	-0.08	0.50	1

Source: Authors' calculation

B-5 Unit root test of developed countries

Variables	Levin Lin	Determination
GDPG	-4.41**	Stationary at level
TRANS	-6.75**	Stationary at level
LCOMM	-4.09**	Stationary at level
LEDU	-5.07**	Stationary at level
ELEC	-5.07**	Stationary at level
EMP	-9.09**	Stationary at level
PC	-1.87**	Stationary at level
POP	-2.92**	Stationary at level
TECH	-1.84**	Stationary at level

Source: Authors' calculation ,
Note: ** represents stationarity at 5% significance value