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Impact of Physical Infrastructure on Economic Growth: Implications for Public Policy

Ayza Shoukat
ayzashouket@gmail.com
Khalil Ahmad
hafizkhalil62@gmail.com

ABSTRACT

This paper intends to explore the impact of public physical infrastructure on economic growth of Pakistan in the long-run with its implications for public policy. This has been done by taking into account three public physical infrastructure indicators like telecommunication, transportation and energy. These indicators are combined through Principle Component Method (PCM). These indicators are selected not only because of their importance for economy but also because they require huge and irreversible investment which is not usually initiated by the private sector. An empirical analysis is conducted on time series annual data from 1972 to 2014 for the economy of Pakistan. By employing PCM, we have constructed infrastructure index for growth analysis. The long-run relationship is constituted by employing Johansen's co-integration technique. The impact of infrastructure index on GDP growth is positive and statistically significant. The results suggest that public physical infrastructure provision certainly improves the economic conditions by contributing towards growth in the long-run. This paper also identifies some guide lines for public policy to ensure efficient public sector investment for the sufficient provision of physical infrastructure. Transparency and financial autonomy should be insured for the selection of public

investment in infrastructure projects. This paper also proposes the public policy reforms for infrastructure expenditures to promote inclusive growth.

Keywords: **Physical Infrastructure, GDP Growth, Infrastructure Index, Public Policy**

Introduction

The relationship between infrastructure and economic growth has been one of the burning issue for researchers as well as for policy makers. It is because the role of infrastructure is important for sustained growth in the long run. The linkage of infrastructure and growth has been well analyzed by many researchers (Prud'homme, 2005; Fourie, 2006; Seethepalli et al. 2007 and Baldwin & Dixon, 2008). But in case of Pakistan, it has not been explored comprehensively. The reasons behind are the difficulties in measuring public physical infrastructure, exploring its relationship with growth and needful policy reforms. The current study has tried to fill this gap. The indicators selected for this study are highly associated with the public benefits and welfare (telecommunication, transportation and energy). But not always the consequences are the same i.e. overlooking the threshold level of infrastructure provision results in either underinvestment or overinvestment (OECD, 2007a, IEA 2007).

Pakistan's economy has passed through a number of policy changes by shifting from private sector economy in the 1960's to the nationalized economy in the 1970's and then moving towards denationalization along with the policies of deregulation and liberalization in the era of the 1980's. The decade of the 1990's was noted because of achieving lowest GDP growth in South Asia, along with high inflation, low investment, inefficient governance and deteriorating infrastructure. However, towards the end of the 1990's, some macro-economic variables started progressing positively. The decade of the 2000's has shown improvement in terms of poverty reduction and job creation with GDP growth rate of 2.58 (Pakistan Economic Survey, 2010). Table-1 shows the passage of growth and infrastructure in Pakistan over the decades.

Table 1

Growth Rate of Infrastructure in Different Decades (Percentage)

Indicators	1972-80	1981-90	1991-00	2001-10
Per capita GDP	2.7	2.9	1.8	2.8
Per capita electricity generation (GWh)	6.1	7.4	2.3	1.9
Length of roads (Km)	4.0	6.3	3.9	0.5
Number of main telephone lines (per 1000 people)	7.8	11.1	11.3	0.2

Source: World Development Indicator (2015), World Bank; Pakistan Economic Survey (various issues), Government of Pakistan.

Economic growth trends of the economy of Pakistan seriously suggest that a sustained path of growth along with a sound economic performance is a necessary condition for placing accurate economic policies and targeted goals for growth which is highly supported by efficient implementation of policies, infrastructure improvements and social sector norms. Where sufficient condition for above relies on internal law and order, governance and external shock to the economy (Mahmood et al., 2008).

This paper constitutes the impact analysis of infrastructure on growth followed by analysis of public policy toward infrastructure investment in Pakistan's economy. The rest of the paper is comprised as; section 2 presents a brief review of literature, section 3 is consist of theoretical framework and selection of variables, section 4 presents the empirical analysis and results discussion where section 5 provides detailed implications for public policy.

Literature Review

The modern society of 21st century allows us to use electric power for home appliances as well as for industrial use. We require roads with an efficient transportation system for shipping goods along with a developed port and airport system for foreign trade. The importance of communication infrastructure needs no introduction. We see that physical infrastructure has become a part of system, affecting society's welfare as well as growth of economy.

Canning and Pedroni (1999) examined the outcomes of infrastructure services provision in the long-run on per capita income of a panel of countries. The period under consideration was from 1950 to 1992. The results of their investigation were contrasting across the countries. Their results showed that on average, paved roads and telecommunication were growth promoting. Besides, roads and telecommunication were undersupplied in some countries and oversupplied in others, whereas electricity generation was under-supplied on average, yet provision of infrastructure was growth contributing. Brenneman and Kerf (2002) on the basis of highly extensive and broad survey obtained highly positive impact of infrastructure availability on education especially for transportation and energy services and on health related issues, in particular, for sanitation, safe drinking water, power and transport sector and lesser for telecommunication.

Sidiqui (2004) checked the effects of energy provision with the fiscal growth for the economy of Pakistan. The study came up with the conclusion that the mounting prices and rising gap between demand and supply of energy resources is a major barrier in the way of economic growth. Among all energy resources, impact of electricity and petroleum is crucial for economic growth of Pakistan. Estache et al. (2005) while analyzing importance of infrastructure regarding growth in sub-Sahara Africa, found positive effects of infrastructure. They have used the data for 25 years. They used GDP per capita at constant prices of 1995 as the explained variable. The explanatory variables are taken from various sectors of economy like investment and education. Share of GDP allocated to investment and ratio of total secondary school enrollment to population of the age group corresponding to secondary school education were the proxy of investment and education. For infrastructure, they used five key measures for major sectors; main telephone lines per 1000 people as a proxy for telecom, consumption of oil in kilotons for electricity, per capita paved roads in kilometers for roads and finally, for water and sanitation, they used percentage of population having developed water and sanitation sources. Their analysis is based on Cobb-Douglas production function. Their analysis revealed that except sanitation, all infrastructure variables are significantly affecting GDP per capita while controlled for other variables (total investment and education). Their results suggest that the phenomenon of growth can be better explained by including infrastructure development with other determinants of growth.

Straub et al. (2008) used a sample of 93 emerging and transitional economies to estimate cross country growth regression. They conclude that number of main telephone lines is striking the economic growth positively and significantly and this outcome is also consistent in the economies with higher income levels. They have recommended physical infrastructure investments as the primary solution to the bottlenecks and socio-economic constraints in developing economies. Egert et al. (2009) found that infrastructure has accelerated the economic growth in OECD countries through enhancement of market competition, economies of scale and number of network externalities. They found a strong and positive impact on long run economic growth across the countries brought about by efficient investments in telecom and power sectors. However, these effects are not extending to transportation sector while incorporating road lengths.

Calderón et al. (2011) looked into the relationship of infrastructure and output growth by analyzing the data set of stock of infrastructure of 88 countries. The time period spanned over 1960 to 2000. To estimate the parameters, they employed PMG (pooled mean group). They found that estimates are statistically significant and also robust to alternate infrastructure measures and dynamic specifications. Ahmed et al. (2013) has used a dynamic EGC model in order to determine the outcomes of investing in physical infrastructure in the Pakistan economy. They analyzed the consequences both at micro and macro level through two approaches of production taxes finance and foreign borrowings. In both cases, they found the positive outcome of public physical investments in Pakistan economy. In addition, in the long-run, formation of public infrastructure yields dramatic reductions in poverty levels along with the gains at macro level.

In the light of existing scientific literature, we have reached the point that the empirical studies determining the relationship of public physical infrastructure and growth are rare for Pakistan. Also existing studies focus on single measure of infrastructure and not the multiple indicators of infrastructure. Further, not a single study has analyzed the importance of implication of public sector regarding infrastructure investment. The present study has tried to address the both issues.

Theoretical Framework and Selection of Variables

Existing studies analyzing the impact of public physical infrastructure on economic growth are mostly based on Cobb-Douglas production function. Their purpose behind this choice is that this functional form is stable with the model of steady state growth when the technological progress is also a part of the model (Barro and Sala-i-Martin, 1995). Also Stephane et al. (2007) found that determining the positive relationship between infrastructure and economic growth by using production function approach is more reliable than the studies considering cross country regressions. This study would also use a hybrid production function for exploring the relationship between infrastructure and economic growth. The traditional production function is transformed by introducing the factors of education and the infrastructure index. Time series data for the time period 1972-2014 for the economy of Pakistan has been used. The data sources are World Bank's online database (World Development Indicators (WDI, 2015) Pakistan Economic Survey (various issues) and International Labor Organization (ILO, 2015). Following model is utilized:

Y = f (Kpvt, ELF, EDU, Z)

Where Y is real GDP of Pakistan's economy, Kpvt is the private capital measured by real private gross fixed capital formation, ELF is labor force measured by employed labor force, EDU is education represented by enrollment at high school and Z is index for infrastructure comprised of three indicators of physical infrastructure. The choice of variables is consistent with the previous studies (Fan and Zhang, 2004; Estache et al., 2005 and Jan et al., 2012). The function is supposed to be exponential and can be linearized by taking the natural log of the above function as:

$$\ln Y_t = \alpha_1 + \alpha_2 \ln Kpvt_t + \alpha_3 \ln ELF_t + \alpha_4 \ln EDU_t + \alpha_5 \ln Z_t + U_t$$

Where α_1 is intercept and α_2, α_3, α_4 and α_5 represent elasticities of GDP and U_t is the independently and normally distributed disturbance term. Where "t" represents the time period of the study which is 1972-2014. A composite index formation is necessary because following a single indicator of infrastructure for the economy would be misleading. For example, in an economy, there is a developed telecommunication sector but improper roads network or in a sector, availability of transport infrastructure is poor but power supply is highly improved. In both cases, availability and access to infrastructure services is misleading. Instead of considering a single indicator, we have constructed a composite index by including multiple indicators of physical infrastructure where these indicators are combined together by employing principal component method (PCM). Following the lines of Estache et al. (2005), the selection of indicators of public infrastructure has been made. The components of infrastructure index are Energy **(**Commercial Consumption of electricity in GWh and Commercial Consumption of oil/petroleum in tons), Transportation (Total length of the roads network in kilometers) and Telecommunication **(**Number of main telephone lines in thousands and number of the post offices in thousands).

Construction of Infrastructure Index through PCM

In order to get a single indicator of infrastructure, we have combined multiple indicators of infrastructure through PCM. These indicators include Energy, transportation and telecommunication. At first stage, all variables are normalized. This is done in order to remove the unit biasness. Following method is employed for avoiding unit biasness:

$$\text{Normalized Values} = \frac{\text{Actual} - \text{Minimum}}{\text{Maximum} - \text{Minimum}}$$

This method of normalizing series is also followed by United Nations Development Program (UNDP) for the construction of Human Development Index (HDI) (UNDP, 1994). After normalization of all series, FPC of each series is generated by using E-Views 7. The FPC of each series is actually the weight assigned to each component of physical infrastructure indicator. After generating FPC, we have multiplied the normalized values of each series with their respective FPC. After doing this, we have added them up. For example:

Z = (Normalized value of first series × FPC of first series) + (Normalized value of second series × FPC of second series) + (Normalized value of third series × FPC of third series)

Following the above mentioned steps, we have constructed our physical infrastructure index. The method of combining components to a single measure is also followed by Alesina and Perotti (1996) and Sánchez-Robles (1998). This method of combining multiple series to a single series is also termed as data reduction technique.

Empirical Analysis and Results Discussion

Time series analysis has been conducted for the economy of Pakistan from 1972 to 2014. While dealing with time series, stationarity of the series is most important. If a series contain unit root, the results can be misleading followed by a spurious regression. In order to avoid this, stationarity of the concerning variables is checked. For unit root, we have conducted Augmented Dickey-Fuller (ADF) test. The results of ADF test statistics are reported in Table-2.

Table 2

ADF Test for Unit Root

ADF Test at Level				
Variables	Without Trend	Prob. Values	Trend and Intercept	Prob. Values
lnY_t	-2.303448	0.1760	-0.850271	0.9516
$lnKpvt_t$	-1.386813	0.5785	-2.720298	0.2346
$lnELF_t$	1.062445	0.9965	-0.963663	0.9376
$lnEDU_t$	-0.399191	0.8994	-1.850290	0.6607
lnZ_t	-1.918498	0.3207	-3.966995	0.0194
ADF Test at 1st Difference				
Variables	Without Trend	Prob. Values	Trend and Intercept	Prob. Values
ΔlnY_t	-4.530171*	0.0008	-4.825474*	0.0021
$\Delta lnKpvt_t$	-3.882004*	0.0050	-3.870353**	0.0233
$\Delta lnELF_t$	-6.351682*	0.0000	-6.585859*	0.0000
$\Delta lnEDU_t$	-4.678289*	0.0005	-4.614842*	0.0036
ΔlnZ_t	-7.319867*	0.0000	-9.193173*	0.0000

Note: * denotes 1% significance level and ** stands for 5% significance level.

The results show that all variables contain unit root that is they non-stationary at level. In this situation, we cannot reject the null hypothesis of non-stationary. However, after taking first difference, all variables become stationary. It means that our series are first difference stationary that is I (1). If the order of integration is same, we can determine long run relationship by using Johansen co-integration technique. As all concerning variables are first difference stationary, it is appropriate to use Johansen co-integration technique. The results of Johansen co-integration are reported in Table-3.

Table 3

Unrestricted Co-integration Rank Test

H_0	H_1	Trace Statistics	Critical Value (At 5% level)	Probability
r = 0*	r ≥ 1	100.3832	69.8189	0.0000
r ≤ 1*	r ≥ 2	67.09088	47.85613	0.0003
r ≤ 2*	r ≥ 3	42.41416	29.79701	0.0011
r ≤ 3*	r ≥ 4	20.26633	15.4947	0.0088
r ≤ 4	r ≥ 5	1.219366	3.84147	0.2695

*rejection of the hypothesis at the 5% level.

According to the results reported in Table-3, null hypothesis $r \leq 0$ is rejected against the alternative hypothesis $r \geq 1$ as trace statistics 100.38 is greater than the critical value of 69.81 at 5 percent level of significance. The null hypothesis of $r \leq 1$ is also rejected in favor of alternative hypothesis of $r \geq 2$ because trace statistic 67.09 is greater than the critical value of 47.85. Along with it, null hypothesis of r ≤ 2 and r ≤ 3 are also rejected in favor of alternative hypotheses of $r \geq 3$ and $r \geq 4$ because trace statistic 42.41 is greater than the critical value of 29.79 and trace statistics 20.26 is greater than the critical value 15.49. We are unable to reject rest of the null hypothesis against the alternative hypothesis because trace statistics is less than the critical value at 5% level of significance. The existence of four co-integrating vectors has confirmed long run relationship. We can say that economic growth is significantly and positively affected by public physical infrastructure in the long run.

If co-integration exists among the variables, the results of OLS are considered to be valid and logical. Long-run co-efficients are determined by applying OLS. The results of OLS are reported in Table-4.

Table 4

Long-Run Relationships

Dependent Variable: LY_t			
Variable	Coefficient	T-Statistic	Prob-Value
Constant	1.173172	1.101660	0.2781
$LKpvt_t$	0.206818	4.232734	0.0002
$LELF_t$	0.449410	3.037122	0.0045
$LEDU_t$	0.397379	4.977373	0.0000
LZ_t	0.042723	2.564388	0.0148
R^2=0.989875 Adj-R^2 =0.988718 F-Statistic= 855.4473 Prob(F-statistic)= 0.000000			

The results show that all independent variables are positively and significantly affecting the GDP growth. One percent increase in infrastructure index (Z) changes the GDP positively by 0.042 percent. The reason behind a high R^2 is that time series data have significant trends over time. In order to deal with it, we have earlier conducted ADF test for unit root and then have used Johansen co-integration technique for determination of long run relationships. Essential diagnostic tests have been applied on the model of our study. The results of these diagnostic tests are presented in Table-5.

Table 5

Diagnostic Tests

Serial Correlation (Breush-Godfrey LM Test) F-statistics (Probability)	ARCH Test (Autoregressive Heteroskedasticity Test) F-statistics (Probability)	Model Specification Test (Ramsey RESET Test) F-statistics (Probability)
0.894116 (0.4203)	0.488391 (0.4893)	0.352872 (0.3169)

The results reported in Table-5 indicate the absence of serial correlation and hetroskedasticity. Also our model is well specified according to the statistics obtained from

Ramsey's RESET test. In order to check the stability of the coefficients, we have applied the cumulative sum (CUSUM) and the cumulative sum of squares (CUSUMsq) on our model. The results are reported in Figure-1 and Figure-2 respectively.

***Figure 1.* Plot of Cumulative Sum of Recursive Residuals**

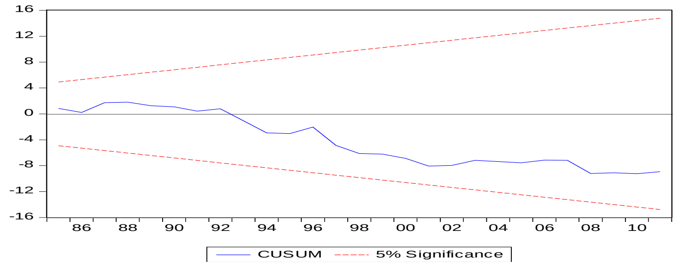
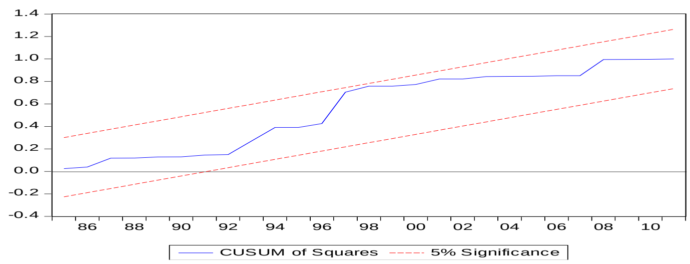


***Figure 2*. Plot of Cumulative Sum of Squares of Recursive Residuals**



Considering the figures, the plots of both the Cumulative Sum (CUSUM) of Recursive Residuals and the Cumulative Sum of Squares (CUSUMsq) of Recursive residuals of our model are between the critical boundaries at five percent significance level. This means that our model is correctly specified.

Implications for Public Policy

Pakistan is one of the developing economies of the world while described in the light of various socio-economic indicators. Inconsistent growth, low education levels, poor health facilities, lack of necessary infrastructure, high rate of inflation and deficit of balance of payments are major characteristics of the economy. The empirical results in the previous section have confirmed that provision of infrastructure is growth promoting in Pakistan. Besides, level of employment, provision of education and private investment are also the growth enhancing factors. We see the level, access and quality of physical infrastructure in Pakistan is undersupplied, particularly, power generation sector (Kafaitullah, 2013). There must be huge and massive investments in order to improve the situation. Particularly, power infrastructure requires instant attention to meet the mounting demand for power and electricity. Thus, alternate power generation sources should be considered. In this regard, construction of new dams and power generating projects would be helpful to maintain the pace of growth. In addition, creating natural monopolies could influence physical infrastructure investment effectively.

Infrastructure provision is provided by the public sector bearing the properties of non-exclusion, non-divisibility and non-rival consumption. While making a decision regarding investment in physical infrastructure, the public sector must make sure that decision making is based on cost benefit analysis and not on political grounds. Moreover, public interest must be preferred over personal interests. Transparency and accountability can prove efficient evaluation. Another important aspect is the overreaching ambition in case of metropolitan cities and rural areas are ignored altogether. A balanced investment based on just approach, by keeping both rural and urban areas side by side is required in case of Pakistan. It is because Pakistan has an agricultural economy and, thus the under provision of physical infrastructure in rural areas would lead to an inefficient agriculture sector.

Fiscal decisions by investing in rural areas would prove to be poverty eliminating as it links the major sectors of economy. For instance, the growth of three sectors (agriculture, industry and services) is linked with three indicators of infrastructure; telecommunication, transportation and energy, without any distinction of rural and urban areas. Though the monetary spending on physical infrastructure increased but in real terms it has declined. That is, how many bridges or kilometers of road or power plants have been constructed instead of expenditures on building infrastructure stock. Provision of these infrastructure facilities would increase the public sector’s efficiency to resolve the bottlenecks in the economy.

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