Significance of Infrastructure Investment for Economic Growth

Younis, Fizza

1 January 2014

Significance of Infrastructure Investment for Economic Growth

(2014)

Fizza Younis

Email Address: fizzayounis@yahoo.com

Abstract

The study attempts to examine the impact of infrastructure investment on economic growth in Pakistan. For this purpose, social and economic infrastructure indices are constructed using Principle Component Analysis and VECM is applied to estimate the long-run as well as short-run relationship between the variables.

The study follows the theoretical background of Barro's (1990) model of government expenditure. The theory suggests that infrastructure investment can have negative impact on economic growth if marginal product of such investment falls below price of capital. The results show that long-run impact of private investment and social infrastructure investment on economic growth is positive and significant while economic infrastructure investment affects economic growth negatively. In short-run, on the other hand, infrastructure investment does not have any significant impact on economic growth. But national savings rate and private investment rate show negative impact on growth. Whereas, price of capital and direct tax have positive impact on economic growth. Diagonastic tests are also performed to test validity of the model.

The results have important policy implications as the study reveals inefficiency of infrastructure investment in Pakistan. There is need to divert resources from economic infrastructure to social infrastructure which has the potential to increase growth rate.

JEL classification: O4 ; O53 ; C5

Keywords: Economic growth; Infrastructure investment; Economic and social infrastructure; Empirical analysis; Vector error correction model

1. Introduction

Efficient infrastructure plays an important role for economic growth. It increases the productive capacity and sustains development. Infrastructure consists of capital-intensive natural monopolies, physical or organizational structures, which are needed for the operation of a society and functioning of an economy.[1] Examples include communication systems, highways, water and sewer lines, health, education and transportation facilities etc. Most of these systems are owned by government. Economic Infrastructure includes transportation and communication facilities, whereas water and sewer lines, health centers and educational institutions are included in Social Infrastructure.[2]

Investment in infrastructure can make market more conducive for business expansion, retention and recruitment. Unfortunately, infrastructure investment in Pakistan has decreased in the last few years from Rs. 272.8 billion in 2007-08 to Rs. 199.7 billion in 2010-11. In addition, budgetary allocation for Transport and Communication has also decreased from Rs. 327.7 billion in 2008-09 to Rs. 287 billion in 2010-11. The energy sector is facing a crisis and currently Rs. 112 billion (2010-11) is invested in this sector. Furthermore, little importance is being paid to social infrastructure and the total health expenditure has declined from Rs. 79 billion in 2009-10 to Rs. 42 billion in 2010-11[3]. Moreover, quality of infrastructure is also deteriorating. Infrastructure Quality score of Pakistan is 3.5 and it is ranked 100 out of 139 countries.[4]

There are a number of studies that show the important linkages between infrastructure development and economic growth. Bougheas *et al.* (1999) emphasized on the accumulation

---

[1] *Infrastructure*, Online Compact Oxford English Dictionary, http://www.askoxford.com/concise_oed/infrastructure

[2] Sheffrin (2003).

[3] Pakistan Economic Survey 2011-12.

[4] http://www.photius.com/rankings/infrastructure_quality_country_rankings_2011.html

of infrastructure capital in developing countries by demonstrating that productive specialization, economic growth and core infrastructure are positively correlated. Various studies show the importance of infrastructure building in Pakistan as well, such as Imran and Niazi (2011) and Shah (1992). But most of these studies do not dwell into the importance and sensitivity of the way capital stock is constructed. Furthermore, these studies do not take into account the impact of social infrastructure. While studying the impact of infrastructure investment on economic growth, it should be taken into account that public capital takes considerable time to affect GDP. [5]

Kularatne (2006) analyzes the impact of social and economic infrastructure on economic growth in South Asia, adapting Barro (1990) theoretical model. The result shows that there is significant and positive impact of infrastructure investment on GDP either directly or indirectly depending on the type of infrastructure. Furthermore, the study analyzes threshold effects for public infrastructure expenditure and concludes that the government can afford to invest at least 1.3 per cent in social and 6 per cent in economic infrastructure. It does not consider whether or not the services provided by the infrastructure are efficient and of highest quality. Further research can be done by increasing the length of time series and taking the quality of infrastructure into account. This may improve the results of the study.

In accordance with the above discussion, objectives of the present study are to demonstrate the significance of social and economic infrastructure investment and the role it can play in achieving sustainable economic growth and to chalk out policy implications. Study is divided into sections and sub-sections. Section two discusses previous studies related to significance of infrastructure for economic growth. Section three is about methodology and

[5] Kularatne (2006).

data description. In chapter four, empirical results are presented. The study is concluded in chapter five. It also gives the policy implications.

2. Literature Review

A vast array of literature is available on the significance of infrastructure development for economic growth. In this section some of these studies are reviewed.

Olaseni and Lagos (2012) determines the importance of social and economic infrastructure investment for Nigeria. According to the World Bank, the country has enough natural and human resources to become one of top 20 economies of the world. The study theoretically analyzes the condition of existing infrastructure. The budget constraint, population explosion, poor governance, corruption and economic sabotage are the reasons behind inadequacy of infrastructure investment. The study also gives recommendations to improve infrastructure. It argues that infrastructure is highly correlated with economic growth, development and can affect poverty reduction. There is no empirical analysis and the arguments are based on the existing literature. According to the paper one of the reasons of inadequate infrastructure investment is insufficient funding. It is recommended to increase funding for infrastructure development. However, the associated opportunity costs and feasibility of diverting funds towards infrastructure development is not analyzed.

Jan *et al.* (2012) also uses Cobb-Douglas production function augmented with index of physical infrastructure to study the relationship between GDP and physical infrastructure. It finds a long-run relation between the two variables. It uses transportation, energy and telecommunication infrastructure and constructs an index of physical infrastructure using principle component analysis.

Nadeem *et al.* (2011) evaluates the effect of social and physical infrastructure on agriculture productivity in Punjab and finds that investment in infrastructure increases the total factor productivity of agriculture and livestock sub-sector. Therefore, more resources should be diverted towards the development of social and physical infrastructure in rural areas. The study uses Cobb-Douglas production function. It does not have economically reasonable or meaningful units of measurement unless $\alpha + \beta = 1$.[6] Furthermore, it does not have any micro-foundations and is used because TFP cannot be measured directly.[7]

Straub and Hagiwara (2011) examines the state of existing infrastructure in developing Asian economies. The study concludes that not only the overall infrastructure in these countries remains below the average world's level but its quality is also poor as compared to the industrialized countries. The study analyzes the link between infrastructure, productivity and growth using both growth regression and growth accounting framework. Cross-country regression shows a positive and significant impact on per capita GDP growth rate because of the accumulation of infrastructure capital. Growth accounting technique reveals that positive impact of infrastructure on TFP is in few countries only. The hypothesis that infrastructure requires a suitable institutional environment to generate significant growth dividends is also tested but the results do not support this hypothesis. These results must be treated cautiously due to the limited data availability.

Straub (2011) critically evaluates the existing macro-level literature about infrastructure and economic growth and development linkages. A sample of 80 different specifications from 30 studies is analyzed. The results reveal that more than half of the studies (i.e. 56 per cent) found a significant positive effect of infrastructure, 38 per cent found no effect and 6 per cent found significant negative effect. Variation in results can be the

[6] Barnett (2007), p. 96.
[7] Walsh (2003).

reason of different data specifications and regional disparities. All these studies may not strictly be comparable because of difference in data and time periods under consideration. In another study Straub (2008) recommends making an effort on the microeconomic part through a strategy to gather data from households and firm level surveys. Munnell (1992) conducts a similar review of the studies containing analysis of public investment. The study concludes that public capital has positive and significant impact on output, investment and employment.

Faridi *et al.* (2011) uses the Solow growth model to study the effect of transportation and telecommunication infrastructure on the economic development of Pakistan. Time series data for the period of 1972 to 2010 is used for that purpose. Transportation is measured in terms of length of roads and telecommunication in terms of telephone lines. The results indicate that transport infrastructure plays significant role in increasing GDP growth where as telecommunication is decreasing the GDP growth of Pakistan. It is concluded that this is caused due to misuse of telecommunication facilities. Hence it recommends that training and skill programs should be devised for labor.

Agénor (2010) proposes a theory of long-run development based on public infrastructure as main engine of growth. It argues that if public governance is adequate then diverting public funds from non-productive activities to the infrastructure capital will help the economy to shift from low growth equilibrium to high growth steady state characterized by high productivity and high savings. The model also has implications regarding choice of technology and the role of the state in fostering private sector growth.

Snieska and Simkunaite (2009) reviews the existing literature on the importance of infrastructure for social and economic growth and development of a country. The study concludes that there is a lack of any unique methodology to analyze socio-economic impact

of infrastructure investment. Researchers have defined it differently, applying different methodologies and using data on different variables, hence, the results also vary. Correlation method is used to evaluate the infrastructure's impact on economic growth in Baltic States. All the three states are from same income group but the results show variation, implying that regional peculiarity is an important issue while studying the relationship of infrastructure and economic growth.

Agenor and Dodson (2006) examines various channels through which public infrastructure can affect economic growth. It highlights the impact of developing infrastructure on investment adjustment cost like durability of private capital and production of health and education services. The endogenous growth model is used to develop a link between health infrastructure and growth. The study draws out the implications for the design of strategies which aim at promoting growth and reducing poverty. But it does not consider the fact that different regions show different behavior regarding infrastructure investment and economic growth.[8]

Calderon and Serven (2004) analyzes the impact of quantity and quality of infrastructure stock on long-run economic growth and income inequality. Simple GDP equation and formal inequality measures are utilized. The results show that infrastructure stock has positive effect on long-run economic growth and negative effect on income inequality. It implies that infrastructure stock building can be used as a strategy for poverty reduction. The paper utilizes panel data set of 121 countries over the time period of 1960-2000. It uses transport, telecommunication and power infrastructure and safe water availability is considered for income inequality. After several tests it concludes that the results are not coincidental and are statistically and economically significant. Although,

[8] Um, N. Paul *et al. (2009)*

social infrastructure variables are not included in this analysis and the panel data set is unbalanced because of the lack of full data in all countries. The issue of regional peculiarity is not discussed either.[9]

Looney (1997) examines the role of infrastructure in the economic expansion of Pakistan. The results show rather complicated role of infrastructure for economic development. On one hand it does not seem to significantly accelerate the development but on the other hand it responds to private investment thus alleviating real bottlenecks. Hashim *et al.* (2009) uses data for the period of 1968-2007 and empirically analyzes the impact of telecommunication infrastructure on economic development in Pakistan. The study shows that teledensity and investment in telecommunication results in higher economic growth rates.

Brock *et al* (1996) analyzes the importance of road infrastructure and its impact on development of Balochistan keeping in view the social impacts of roads in remote areas. The study argues that Balochistan does not have adequate road network. A very simple model is used for empirical analysis but the efficiency and equity aspects are also taken into account. The concept of development is far complex than the paper implies. Human development and environmental preservation should also be taken into account.

It is a well established fact that infrastructure investment plays an important role in the process of economic growth.[10] It has a profound and positive effect on the total factor productivity but the magnitude of this effect varies in different regions of the world (Straub *et al.* (2009)). Social and economic infrastructure helps in human development thus making life easier and increasing the factors' productivity. Literature shows that investment in infrastructure has positive impact on economic growth, therefore, this study analyzes impact

[9] For more detail see Simkunaite *et al.* (2009).
[10] JBIC et al. (2005)

of social and economic infrastructure on economic growth in Pakistan to facilitate future policies.

3. Theoretical Background of the Model

To analyze the significance of infrastructure for economic growth and development, present study readapts Barro's (1990) theoretical model[11]. According to the theory, endogenous-growth model can be utilized to study the impact of government financed services on utility or production.

The model aims at disentangling the impact of public infrastructure investment from private investment in capital stock. Assuming that there is balance budget constraint and that public investment in social and economic infrastructure is financed by tax on output, theoretical link between output, government investment in infrastructure and private investment can be derived as follows;

Assume that a production function with Cobb-Douglas technology exists. The production function is assumed to be labor-intensive.

$$y = AI_s(I_e)^{\beta}k^{1-\beta}, 0 < \beta < 1 \dots 3.1$$

Where, y is output per worker, A is technology, $I_s$is social infrastructure stock per worker, $I_e$is economic infrastructure stock per worker and k is private capital stock per worker. The budget constrain is,

$$g = P_sI_s + P_eI_e = \tau y \dots 3.2$$

Where, $P_s$is the price of $I_s$and P_e is the price of I_e. The house hold utility function is given as follows;

[11] For more details see Kularatne (2006) and Keho (2011).

$$U = \ln C_t \ldots 3.3$$

Where, C_t is consumption per worker at time t. For this household's maximization problem the steady state growth rate is given as follows (where ρ is a constant for time preference);[12]

$$\gamma = (1-\tau)(1-\beta)AI_s(I_e/k)^{\beta} - \rho \ldots 3.4$$

Assuming that the rate of depreciation is zero and using balance budget constraint we can derive the following results;

From equation 3.2 $\tau = \frac{P_s I_s + P_e I_e}{y}$ and by putting it in equation 3.4 we get 3.5 and equations 3.6a and 3.6b follows.[13] The steady state represents the growth rate of output. The results show that government investment in economic and social infrastructure can increase the growth rate (γ). But the increase will be within limits. As shown by the equations the marginal rates of social and economic government investment should not fall below the prices P_s and P_e respectively.

$$\gamma = \left(1 - \frac{P_s I_s + P_e I_e}{y}\right)(1-\beta)AI_s(I_e/k)^{\beta} - \rho \ldots 3.5$$

Differentiating the above equation with respect to I_s and I_e, we can derive following two results (Kularatne (2006));

$$\frac{\partial \gamma}{\partial I_s} > 0 \; iff \frac{\partial y}{\partial I_s} > P_s \ldots 3.6a$$

$$\frac{\partial \gamma}{\partial I_e} > 0 \; iff \frac{\partial y}{\partial I_e} > P_e \ldots 3.6b$$

[12] This equation is taken from Barro's (1990) result, on which theoretical model is based.
[13] For more details see Kularatne (2006).

The model suggests that investment in social and economic infrastructure can prevent diminishing returns to capital. But once the marginal product of public infrastructure capital falls below price of capital, it can have a negative impact on output growth rate.

From the results (based on theory) it can be summarized that[14],

(a) Output is affected by social and economic infrastructure investment.

(b) Private investment is indirectly affected by social and economic infrastructure investment.

(c) Increase in output increases tax which in turn increases public infrastructure investment.

(d) Increase in public infrastructure investment beyond a limit can crowd out private investment thus decreasing private capital stock.

An array of literature is available analyzing the impact of infrastructure on total factor productivity and economic growth using production function and growth accounting techniques. Very few studies have strived at analyzing the impact of infrastructure investment on economic growth directly and not all studies differentiate between social and economic infrastructure. Furthermore, there are a number of drawbacks of using standard production function techniques including possible presence of reverse causality between infrastructure investment and output, as pointed by Romp and de Haan (2005), Straub (2011) and Bom and Ligthart (2008). There is a need to use a more comprehensive estimation technique which deals with unique case of the country under discussion. In present study some of these issues have been dealt with.

[14] Kularatne (2006).

3.1 Data and Econometric Methodology

Variables used to study the significance of economic and social infrastructure include gross value added[15] per capita, social & economic infrastructure indices, private investment rate, national savings rate, price of capital and interest rate. Economic and social infrastructure indices are used as proxy for respective infrastructure investment rates. Gross value added per capita is calculated to be used as an indicator of economic growth rate.[16] Purpose of this study is to estimate the impact of social and economic infrastructure on economic growth rate. Economic infrastructure index, social infrastructure index and price of capital (POC) are self constructed variables. Infrastructure indices are constructed because there are a number of variables which represent infrastructure. It would not be possible to take all those factors as regressors due to constraints of degrees of freedom. Hence composite indices are constructed for economic and social infrastructure.

Index for Social and Economic Infrastructure

The social and economic infrastructure indices are constructed by using Principle Component Analysis (PCA) as follows;

$$I = \frac{1}{n}\sum_{j=1}^{n}(\sum_{i=1}^{n} b_{ij})x_j$$

$$= \frac{1}{n}\Big[\begin{matrix}(b_{11} + b_{21} + \cdots + b_{n1})x_1 + \\ (b_{12} + b_{22} + \cdots + b_{n2})x_2 + \cdots + (b_{1n} + b_{2n} + \cdots + b_{nn})x_n\end{matrix}\Big] \quad \ldots 3.7$$

Where, b_{ij} represents the components of matrix B and x_j is the different measures of physical infrastructure. The matrix B is calculated by obtaining the principal eigenvectors from the data set and applying the varimax rotation to smooth out the trends thus facilitating

[15] GVA= GDP - taxes on products + subsidies on products

[16] Term economic growth rate will be used for gross value added per capita in chapter 5 of this study.

more appropriate interpretation. An advantage of using PCA technique for developing infrastructure index is that although various types of infrastructure correlate with each other, in many cases they do not capture the overall availability of infrastructure. Therefore, a composite index can be developed which captures the variance in different variables.[17]

To construct economic and social infrastructure indices, the physical capital stock of various infrastructures is employed. Economic Infrastructure includes;

- Transport Infrastructure is measured by total road length (km), railway route (km), air transport (km flown) and cargo handled at sea ports (ton)
- Energy Infrastructure is measured by total electricity generated (Gwh).
- Communication infrastructure is measured by the number of telephone lines, mobile phone, broad band internet subscribers and total post offices.

Social infrastructure index is constructed separately that includes;

- Health Infrastructure is number of all type of health establishments.
- Education Infrastructure is number of different types of educational institutes.

Price of Capital (POC)

The user price of capital (POC) is obtained as the price index of capital goods (P) (machinery, etc.) multiplied by interest rate on bank advances (R) plus the depreciation rate (δ) minus the inflation (growth) rate in the price index of capital goods. That is:

$$POC_t = P_t^M[R_t + \delta - \left\{\frac{P_t^M}{P_{t-1}^M} - 1\right\}] \dots 3.8$$

[17] Kumar, Nagesh and De, Prabir (2008)

After specification of model and collection of required data, the next step is to estimate the model by selecting an appropriate technique. In the first step, stationarity of all the variables is tested by employing ADF test for unit root. ADF results are presented in table 1. It shows that all the variables are non-stationary at level but these are stationary at first difference. Price of capital is also stationary at first difference but only when trend and intercept both are included.

OLS can not be used to estimate the model without making the variables stationary otherwise it gives misleading results.[18] And taking difference of the variables limits the result to only short-run. It is, therefore, necessary to conduct co-integration analysis before estimation of the model. If co-integration exists, then error correction model can be estimated which gives short-run as well as long-run relationship. Otherwise only short-run relationship is estimated.

Granger (1981) introduced the concept of co-integration. Among others, Phillips (986, 1987), Engle and Granger (1987), Engle and Yoo (1987), Johansen (1988, 1991, 1995a) further elaborated the concept. Its formal definition given by Engle and Granger (1987) states that, "Time series y_t and x_t are said to be cointegrated of order d, b if d ≥ b ≥ 0, written as $y_t, x_t \sim CI\ (d, b)$, if (a) both series are integrated of order d ≥ 1, and (b) there exists a linear combination of these variables, say $\beta_1 y_t + \beta_2 x_t$ which is integrated of order d-b. The vector $\{\beta_1, \beta_2\}$ is called the cointegrated vector."

Macroeconomic models may give spurious regression if the variables are non-stationary. Taking their difference can also cause problems because if two variables are accurately specified and we take their difference then we are also taking the difference of the error term. Secondly the model might not give unique long-run relation in this case. The co-

[18] Mahadeva and Robinson (2004).

integration technique is based on the idea that even when two variables are rising over time they can be linked with a common trend if there was any long-run relationship between them.

A variety of techniques are available in the literature to test for co-integration. Among these, Engle-Granger technique, Johansen co-integration and ARDL technique are the most popular. However, Engle-Granger is suitable only for two variable models. In case of multivariate models Johansen and ARDL techniques are used. This study uses Johansen co-integration technique to test for co-integration and the estimation of VECM because there are more than two variables in the model, and hence, there is a possibility of more than one co-integrating vector may exist.[19]

In the last step, to check validity of the model we employ carious diagonnastice tests. These include Breusch-Godfrey serial correlation LM test, Breusch-Pagan-Godfrey for heteroskedasticity and Jarque-Bera test for normality. Impulse response and variance decomposition are also emplyed. Graphical representations are used to draw conclusions. Time path of the dependent variables in the model to shocks from all the explanatory variables can be produced using impulse response.

4. Results and Discussion

Since, all the variables are non-stationary at level and stationary at first difference, therefore, we proceed to estimate ECM. In the first step, Johansen technique is applied to test co-integration. VAR model is used to select the appropriate lag length for co-integration test. The maximum lag length of two is selected because we want to preserve as much degrees of freedom as possible.[20] The results presented in table 2 in show that lag length one is selected

[19] In case there is n number of variables then n-1 co-integrating vectors can exist and Engel-Granger approach cannot treat the possibility of more than one co-integrating relationship.

[20] Haider and Butt (2006).

in all the criteria given. After the selection of appropriate lag length, the next step is to identify the appropriate model for the co-integration test.

Co-integration is analyzed between gross value added per capita, economic infrastructure investment rate, social infrastructure investment rate and private investment rate. Direct tax rate, national savings rate, price of capital and interest rate are taken as exogenous variables. The results of Johansen co-integration test are reported in table 3. The results show that there is one co-integrating vector (r) as trace test as well as maximum eigen value test reject the null hypothesis of no co-integration (i.e. both statistics are greater than their critical values) but fail to reject the null hypothesis of no more than one integration vector.

It implies that co-integration exists among the variables i.e. gross value added per capita, economic and social infrastructure investment rate and private investment rate, and one co-integrated vector exists. Hence we may now proceed to estimate VECM.

In the next step VECM is applied and the results are reported in the table 4. Objective of the study is to estimate the impact of social & economic infrastructure investment on economic growth. Objective can be achieved by analyzing the equation for gross value added per capita. Moreover, the coefficients of long-run adjustment factors are insignificant for all other equations. In VECM framework this means that these variables do not play any role in bringing the normalized variables in long-run equations to equilibrium. Thus equations for these variables can be dropped from the model.

Next the diagnostic tests are performed to check the validity of the VECM. The results are shown in table 5. The VECM pass all diagnostic tests. Hence there is no serial correlation, heteroscedasticity or presence of ARCH in the model and the error terms follow normal distribution. It means that the model is a good fit.

For Gross Value Added per Capita the long-run adjustment coefficient is significant, as well as negative which shows the presence of stable long-run relationship between economic growth, private investment and social & economic infrastructure investment. It is -0.7285. It means that the speed of adjustment towards equilibrium (in one year as the data is annual) is 72.87 per cent and its negative sign indicates that long-run relationship is not explosive and it is stable. The value is between 0~1 which means that it is reasonable i.e. the model is stable. The results show that in the long-run Economic Infrastructure investment Rate has negative impact on economic growth where as Private Investment Rate and Social Infrastructure Rate has positive impact on growth in Pakistan.

Trend is positive and significant. The long-run and short-run impacts of independent variables on gross value added per capita are presented in table 4. Taking the long-run co-integration equation, study concludes following;

- A one percent increase in economic infrastructure investment rate is associated with a 0.015 per cent decrease in gross value added per capita and vice versa.
- A one percent increase in social infrastructure investment rate will increase the gross value added per capita by 0.013 per cent and vice versa.
- A one percent increase in private investment rate increases gross value added per capita by 0.073 per cent and vice versa.

The results show that in the long-run social & economic infrastructure investment rates and private investment rate effect gross value added per capita which represents economic growth rate. In other words increase in social infrastructure investment rate and private investment rate increases the rate of economic growth. Whereas, increase in economic infrastructure investment rate, decreases the economic growth rate. The results are in accordance with the theory, which states that economic infrastructure has diminishing

marginal product, social infrastructure does not show diminishing marginal product and private investment has a positive impact on economic growth. The result is not in accordance with past literature related to infrastructure's effect on economic growth in Pakistan. Most of the studies found significant positive impact of infrastructure on economic growth. Although these studies do not differentiate between economic and social infrastructure and most of them used transportation and communication infrastructure only, to study its impact on economic growth.

The data shows that investment in economic infrastructure has been higher than the investment in social infrastructure which has a positive impact on economic growth. The results are not in accordance with the prior literature available because it does not employ only economic infrastructure but also includes social infrastructure data. This differentiation makes it possible to separate the impact of economic infrastructure investment and social infrastructure investment. Social infrastructure represents human capital as it includes education and health infrastructure. In other words, the study verifies the importance of human capital development. There are various studies which show negative or insignificant impact of public investment in Pakistan.[21] On the other hand, infrastructure shortage has also been found (Samad and Ahmed (2011)) but the shortage lies in water, irrigation, transport and energy sector (World Bank (2001)). Infrastructure plays a significant role in achieving sustainable economic growth.

The short-run relationship between the variables is summarized as follows;

- Social & economic infrastructure investment rates are insignificant indicating that these variables do no effect economic growth rate in the short-run. Interest rate does not seem to have any short-run impact on economic growth either.

[21] See Ghani and Din (2006), Rehman *et al*. (2010) and the Planning Commission (2011).

- Private investment rate shows a negative impact on economic growth rate in short-run dynamics of the model. Increase of one percent in private investment rate decreases gross value added by 0.0999 per cent and vice versa.
- One percent increase in direct Tax increases economic growth rate by 0.0005 per cent and vice versa. Coefficient of direct tax is significant.
- Price of capital also has a positive and significant impact on gross value added. An increase of one percent in price of capital increases economic growth rate by 9.13E-08. The value is very small and is almost negligible.
- National savings rate shows a negative and significant impact on economic growth rate in short-run. If national savings rate is increased by one percent then gross value added per capita decreases by 0.0285 per cent and vice versa.

The short-run and long-run relationship can differ in both direction and magnitude. The reason is that in the long-run a number of business cycles are included. Similarly other stochastic shocks play a role in determining long-run and short-run dynamics of the model. The insignificant impact of economic and social infrastructure rate on economic growth rate is according to what theory suggests as there is sufficient gestation period required for the infrastructure investment to effect economic growth. The insignificance of interest rate as an exogenous variable is also predictable. Interest rate affects investment and thus overall economic growth. The theory does not suggest direct relationship between interest rate and economic growth. It is taken as a control variable only. These variables can now be dropped from the short-run equation of the model.

Positive impact of price of capital can be explained, as controlled inflation can stimulate the economy and in this case it shows a short-run relationship exists. But persistence of high inflation in the long-run can be harmful for the economy. Private

investment rate and national savings rate have significant negative impact on economic growth rate in the short-run. The negative sign of private investment rate in the short-run is not according to the theory. It shows inefficiency of the investment but the impact becomes positive in the long-run. According to literature inefficient public investment can be responsible for the negative effect of the private investment as it can crowd-out the positive impact of private investment.[22] In the long-run the sign changes and the effect of private investment becomes significantly positive.

Although in more recent studies it is advised that the impact of national savings on economic growth should be re-evaluated. But the present study shows a significant impact of national savings rate in short-run. According to the theory the relationship between savings rate and economic growth is ambiguous. The causality may run in one or both directions but the empirical evidence is inconclusive. The results vary for different economies. The literature review suggests that national savings may not have any direct impact on economic growth, whereas, economic growth may have a direct impact on savings rate. Thus effect of national savings on economic growth may be overstated in the past.[23] Therefore, it is difficult to say whether present results are accurate or not. But it can be explained when government savings as part of national savings are considered as well. The public investment is inefficient in Pakistan as the long-run equation of the model suggests. The investment in economic infrastructure has been inefficient. When the investment is inefficient and resulting in a decrease in economic growth rate then national savings will also have a negative impact on growth.

The impulse response and variance decomposition are performed on the estimated model and the results are shown in figures 4.1 and 4.2 respectively. The Impulse response

[22] Virmani (2006).
[23] See Caroll and Weil (1994).

shows the transfer of shocks from one variable to the other through the dynamic structure of the model. As equation of gross value added per capita is the equation of interest in this model, we observe the transfer of shocks from all endogenous variables to gross value added per capita only. Cholesky method of decomposition is used and the variables are orders as follows; gross value added per capita, economic infrastructure investment rate, social infrastructure investment rate and private investment rate.

It is seen that gross value added per capita responds positively to its own shocks but does not return to equilibrium in period 20. It responds negatively to the shocks in economic infrastructure investment rate and again does not return to equilibrium. It responds negatively to private investment rate but after period 3 the response becomes positive. This result also verifies negative impact of private investment on gross value added per capita in the short-run. Gross value added per capita's response to shocks in social investment rate is also positive and permanent. In all cases equilibrium is not reached in period 20, implying that all shocks have a permanent impact on gross value added per capita.

The variations in gross value added per capita are separated into component shocks to structural equation using variance decomposition and the results are presented in figure 4.2. It is important because it shows how much each variable accounts for in the variations to the dependant variable. The result shows that gross value added per capita accounts for most of the variations in itself. From period one to four it accounts for more than 60 per cent of the variations. After that a decreasing trend is observed and by period 20 it accounts for about 20 per cent of the variations in itself.

Second most important variable to explain the variations in gross value added per capita is social infrastructure investment rate. Between periods four to 20, it accounts for 20 per cent to about 38 per cent of the variations in gross value added per capita. Economic

infrastructure investment rate accounts for 20 per cent of the variations at first but then it decreased to around 15 per cent. Private investment rate accounts for only about 2 per cent of the variations in gross value added per capita at first but then its impact becomes more profound and it too accounts for about 15 per cent of the variations by period 20. This result shows that social & economic infrastructure investment rates have more significant impact on economic growth rate in the long-run rather than in short-run.

5. Conclusion and Policy Implications

The purpose of this study is to estimate the impact of infrastructure investment on economic growth. It readapts Barro's (1990) model and utilizing time series analysis estimates the significance of social and economic infrastructure in economic growth of Pakistan. The results show that social infrastructure investment has a positive impact on growth where as economic infrastructure has a negative impact on growth. According to the theory it suggests that the economic infrastructure investment might have crossed the threshold level after which it impact becomes negative or it might be inefficient. The study does not measure the efficiency of the infrastructure capital therefore further research should be conducted to investigate the cause of negative impact of economic infrastructure on growth.

Social infrastructure has a positive and significant impact on economic growth which suggests that the government should invest more in this sector. As it has the potential to increase the growth rate of the economy. The private investment rate also effects economic growth positively indicating a need for policy measures which will give incentives to the private investors to invest more. On the other hand income tax has a positive and significant impact on economic growth in the short-run. This means that reducing income tax as a policy measure is not advisable. Furthermore, negative impact of national savings rate and private

investment rate in the short-run indicate that there is a need to reevaluate the government investment policies and invest in efficient sectors to increase the growth rate in the country.

References

Agénor, Pierre-Richard (2010). A Theory of Infrastructure-led Development. *Journal of Economic Dynamics and Control*, *Elsevier, 34*(5), 932-950, May.

Agenor, Pierre-Richard &Moreno-Dodson, B. (2006). Public Infrastructure and Growth: New Channels and Policy Implications. *The World Bank,* Policy Research Working Paper Series 4064.

Asterios, D. & Stephen, G. H. (2011). *Applied Econometrics* (2nd edition). Palgrave MacMillan.

Bom, P. & Ligthart, J. (2008). *How Productive is Public Capital? A Meta-Analysis*. Institute for Economic Research, Munich, Working Paper No. 2206.

Bougheas S., Demetriades P. O. & Mamuneas T. P. (1999). Infrastructure, Specialization and Economic Growth. *Canadian Journal of Economics, 33*(2), 506-522.

Brock, R. W. *et al*. (1996). Economic Development and Infrastructure: The Case of Balochistan Province. *The Pakistan Development Review, 35*(1), 86-93, Spring.

Calderon, C. & Serven, L. (2004). *The Effects of Infrastructure Development on Growth and Income Distribution*. The World Bank, Policy Research Working Paper Series 3400.

Economic Advisory Wing. (2011). *Economic Survey*. Islamabad: Ministry of Finance Government of Pakistan.

Economic Advisory Wing. (2012). *Economic Survey*. Islamabad: Ministry of Finance Government of Pakistan.

Enders, W. (2004). *Applied Econometric Time Series* (2nd edition). John Wiley & Sons Inc.

Faridi, Z. M., Malik, S. M. & Bashir, F. (2011). Transportation, Telecommunication and Economic Development in Pakistan. *Interdisciplinary Journal of Research in Business, 1*(7), 45-52, July.

Gramlich, E. M. (1994). Infrastructure Investment: A Review Essay. *Journal of Economic Literature, 32*(3), 1176-1196.

Hashim, S., Zaman, K., Munir, A. & Khan, A. (2009). Telecom Infrastructure and Economic Development of Pakistan: An empirical Analysis. *International Research Journal of Arts and Humanities, 37*, 147 – 156.

Jan, S. *et al.* (2012). Physical Infrastructure and Economic Development in Pakistan. *Middle-East Journal of Scientific Research, 11*(2), 216–220.

JBIC, ADB & WB (2005). *Connecting East Asia, A New Framework for Infrastructure*. The World Bank.

Kularatne, C. (2006). *Social and Economic Infrastructure Impacts on Economic Growth in South Africa*. Presented at the Development Policy Research Unit (DPRU) Conference, Johannesburg, South Africa, October.

Kumar, N. & De, P. (2008). East Asian Infrastructure Development in a Comparative Global Perspective: An Analysis of RIS Infrastructure Index, *Research and Information System for Developing Countries (RIS),* India.

Looney, E. R. (1997). Infrastructure and Private Sector Investment in Pakistan. *Journal of Asian Economics, 8*(3), 393-420, JAI Press Inc.

Munnell, H. A. (1992). Policy Watch: Infrastructure Investment and Economic Growth. *The Journal of Economic Perspectives*, *6*(4), 189-198, Autumn.

Nadeem, N., Khalid, M. & Javed, I. M. (2011). Impact of Social and Physical Infrastructure on Agricultural Productivity in Punjab, Pakistan-A Production Function Approach. *Pakistan Journal of Life and Social Sciences, 9*(2), 153-158.

Olaseni, M. & Lagos, Y. (2012). Vision 20:2020 and the Challenges of Infrastructural Development in Nigeria. *Journal of Sustainable Development, 5*(2), February.

Paul, C. (2011). Infrastructure, Rural Electrification and Development. *Energy for Sustainable Development, 15*, 304-313.

Phang, S. (2003). Strategic Development of Airport and Rail Infrastructure: The Case of Singapore. *Transport Policy*, *10*, 27-33.

Romp, W. & Haan, J. (2005). *Public Capital and Economic Growth: A Critical Survey*. European Investment Bank Papers.

Sharma, S. (1996). *Applied Multivariate Techniques* (2nd edition). John Wiley & Sons Inc.

Smith, L. I. (2002). A Tutorial on Principal Components Analysis, *Cornell University, USA*.

Snieska, V. & Simkunaite, I. (2009). Socio-Economic Impact of Infrastructure Investments. *Inzinerine Ekonomika-Engineering Economics, 3.*

Straub, S. & Terada-Hagiwara, A. (2011). Infrastructure and Growth in Developing Asia. *Asian Development Review*, *Asian Development Bank, 28*(1), 119-156.

Straub, S. (2011). Infrastructure and Development: A Critical Appraisal of the Macro-level Literature. *The Journal of Development Studies*, *Taylor and Francis Journals, 47*(5), 683-708.

Straub, S. (2008). *Infrastructure and Growth in Developing Countries: Recent Advances and Research Challenges*, ESE Discussion Papers 179, Edinburgh School of Economics, University of Edinburgh.

Um, N. P., Straub, S. & Vellutini, C. (2009). *Infrastructure and Economic Growth in the Middle East and North Africa*, Policy Research Working Paper, 5105, The World Bank, October.

Vemuri, R. S. & Bandias, S. (2005). Telecommunications Infrastructure Facilitating Sustainable Development of Rural and Remote Communities in Northern Australia. *Telecommunications Policy, 29*, 237-249.

Virmani, A. (2006). *Lessons of Government Failure: Government Goods Provision and Quality of Public Investment.* Planning Commision, India, Working Paper no. 2/2006-PC.

Table 1: Augmented Dickey Fuller Test[24]

	Level			First Difference		
Variable	**Intercept**	**Intercept & Trend**	**None**	**Intercept**	**Intercept & Trend**	**None**
lnGVAC	0.8405	0.9370	1.0000	0.0000	0.0000	0.0898
EIR	0.9270	0.7117	0.8270	0.0000	0.0000	0.0000
SIR	0.6807	0.9463	0.7052	0.0019	0.0038	0.0001
lnPIR	0.5153	0.7427	0.3539	0.0000	0.0000	0.0000
lnNSR	0.8828	0.9899	0.8612	0.0000	0.0000	0.0000
POC	1.0000	0.9922	0.9994	0.9417	0.0530	0.9650
lnDT	0.1862	0.2546	0.3496	0.0000	0.0000	0.0000
IR	0.0231	0.2808	0.5717	0.0001	0.0005	0.0000

[24] The lag length is determined using Schwartz criterion. The table gives P values of t statistics at level and first difference

Table 2: Selection of Lag Length

Lag	LogL	LR	FPE	AIC	SC	HQ
0	86.94082	NA	1.49e-07	-4.365306	-4.192929	-4.303976
1	226.1824	241.8406*	2.29e-10*	-10.85170*	-9.989816*	-10.54505*
2	239.9415	21.00080	2.66e-10	-10.73376	-9.182366	-10.18179

*Indicates lag order selected by the criterion. LR: Sequential modified LR statistic (each test at 5 per cent level of significance), FPE: Final prediction error, AIC: Akeike information criterion, SC: Schwartz criterion and HQ: Hannan-Quinn information criterion.

Table 3: Johansen Cointegration Test

	Trace Test				Maximum Eigen Values			
Eigen Value	Hypothesized		Trace	0.05		Hypothesized	Max. Eigen	0.05
	H0	H1			H0	H1		
0.642959	r=0	r>0	71.55523**	62.99	r=0	r=1	39.13632**	31.46
0.414525	r≤1	r>1	32.41891	42.44	r=1	r=2	20.34263	25.54
0.181708	r≤2	r>2	12.07627	25.32	r=2	r=3	7.620388	18.96
0.110646	r≤3	r>3	4.455887	12.25	r=3	r=4	4.455887	12.25

** indicates the rejection of null hypothesis of no cointegration. The critical values at 5 per cent level of significance are taken from Mackinnon-Haug-Michelis (1992).

Table: 4 Vector Error Correction Mechanism (VECM)

	Long-run Impact	**Short-run Impact**
Dependant Variable	lnGVAC	D(lnGVAC)
Intercept	4.243881	-0.009658
Trend	0.007757	
Error Correction Term	0.728758	
EIR(-1)	-0.015439	
lnPIR(-1)	0.073384	
SIR(-1)	0.013402	
D(ln(GVAC(-1)))		0.205541
D(EIR(-1))		-0.004033
D(lnPIR(-1))		-0.099898
D(SIR(-1))		0.000548
D(DT)		0.077122
D(lnNSR)		-0.028518
D(POC)		9.13E-08
D(IR)		0.000843

Table: 5 Diagnostic Tests

Breusch-Godfrey Serial Correlation LM Test (H_0: No Serial Correlation)			
F-statistic	0.03456	Prob. F(1,27)	0.8539*
Obs. R-squared	0.04858	Prob. Chi-Square(1)	0.8255
Breusch-Pagan-Godfrey For Hetero. (H_0: No Heteroscedasticity)			
F-statistic	0.6061	Prob. F(16,21)	0.8448*
Obs. R-squared	12.0044	Prob. Chi- Square(16)	0.7437
Jarque-Bera Normality Test (H_0: Error Terms Are Normal)			
Jarque-Bera Stat	1.401	Probability	0.4963*
Hetroscedasticity Test: ARCH (H_0: No ARCH)			
F-statistic	2.2578	Prob. F(16,21)	0.1419*
Obs. R-squared	2.2422	Prob. Chi- Square(16)	0.1343

*Shows failure to reject null hypothesis

Figure: 4.1 Graphical Representation of Impulse Response

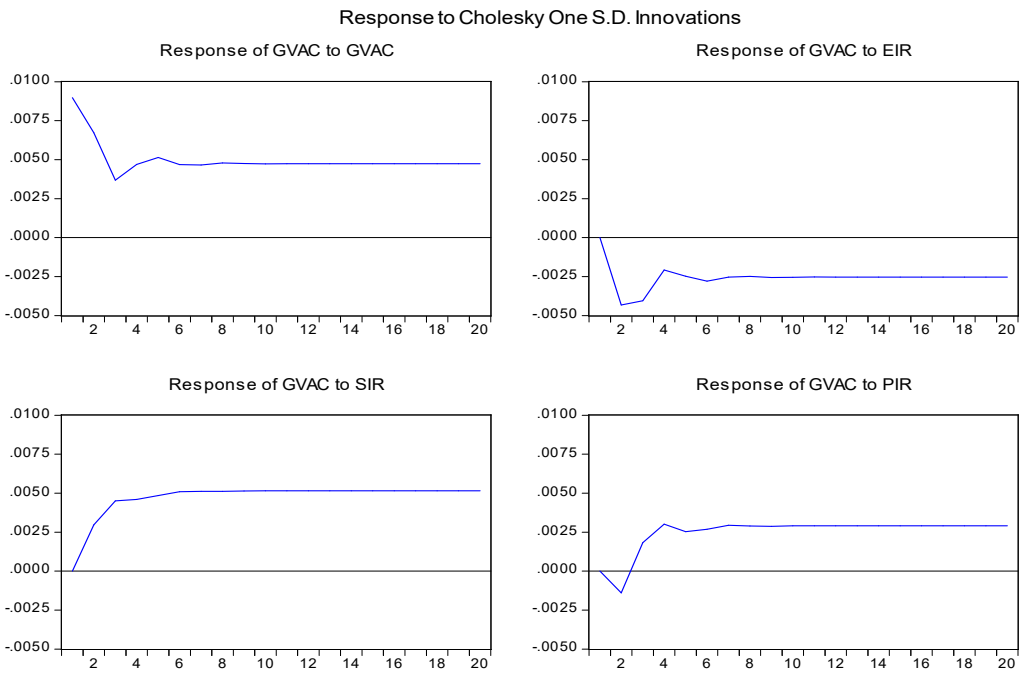

Figure: 4.2 Graphical Representation of Variance Decomposition