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Infrastructure and Growth

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1. INTRODUCTION

Physical infrastructure stock development has many important direct and indirect effects to an economy. These effects operate through various channels. For example, through labor productivity gains resulting from improved information and communication technologies, reductions in time wasted commuting to work and stress, improvements in health and education, and through improvements in economies of scale and scope throughout the economy. On the supply side, there is both a direct channel (infrastructure capital stock serves as a production factor), and an indirect one (improved infrastructure affects technological progress). From a demand side point of view, infrastructure provides people with services they need and want—water and sanitation; power for heat, cooking, and light; telephone and computer access; and transport.

In Pakistan, low infrastructure development in the past two decades has become binding constraints to production sector in the economy. It has also impacted to the direct consumption of the household sector and thereby reducing the overall welfare of the general public. Continuous underinvestment since the last few years has further aggravated the situation in Pakistan. Frequent cutbacks in the PSDP and the low levels of allocations imply that there is a need for strategic selection of the projects/programmes, specifically in the energy sector, to maximise the effectiveness of the development plans. Inadequate and poor quality infrastructure in Pakistan has held back not only economic activity but has also drastically reduced the quality of life of the masses. Thus, the government of Pakistan should place infrastructure development very high on its action agenda.

Table 1 gives decade-wise growth rates of different infrastructure indicators and per capita GDP growth in Pakistan. All of the infrastructure indicators have decreasing trend over the period and are very low in the last two decades. The fastest growth in electricity generation is observed in the 80s, largely because of the commissioning of the Tarbela Dam. Per capita water availability for agriculture appears to have consistently declined over the last four decades. The 80s also saw relatively rapid expansion in the road network but has visibly slowed down during the last decade.

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Table 1

Decade-wise Growth Rate of Different Types of Infrastructure and Per Capita GDP of Pakistan, 1976 to2011

(Percentage)

	1970s*	1980s	1990s	2000s	2010-11
Per Capita GDP growth	2.7	2.9	1.8	2.8	0.8
Per Capita Electricity Generation (Gwh)**	6.1	7.4	2.3	1.9	-2.6
Per Capita Water Availability (MAF)	–1.5	–1.0	–1.2	–2.3	0.5
Length of Roads (Kilometers)	4.0	6.3	3.9	0.5	–1.6
Telecommunications					
– Number of Telephone Lines (per 1000 people)	7.8	11.1	11.3	0.2	-7.8
– Mobile Phones availability (per 1000 people)	–	–	45.7***	72.3	2.2

Source: World Development Indicators, World Bank.
Pakistan Economic Survey, Government of Pakistan.
* From 1975-76 to 1979-1980
**Adjusted for transmission losses.
*** From 1995-196 to 1999-2000.

There has been a virtual explosion in the telephone network during the 70s, 80s and 90s, however, this has decreased very sharply in the last decade because of massive usage in the mobile phones, whose usage has increase by 72 percent during the same period. Also from the Table 1, we can see that infrastructure appears to relate significantly to per capita GDP growth. This is particularly true in the decades of 70s and 80s mainly through accumulating huge infrastructure stock. In 2010-11, most of the infrastructure variables have a negative growth rate only the mobile phones and water availability indicators have shown positive growth, although, the growth rate is very minor compare to early periods. Note that electricity generation has negative growth in this year. This is the main reason of almost very low growth in the per capita GDP.

Against this background, the objective of this paper is, first, to find out the determinants of the total factor productivity (TFP). In this exercise our focus will mainly be on the public infrastructure stock as an important determinant of TFP. Second, to determine how infrastructure stock impacts economic growth, specifically, to determine which types of infrastructure, that is, electricity generation, roads highways, power, telecommunications, irrigation, etc., are more effective from the viewpoint of raising the growth rate of the economy as a whole. Implications of the research on the allocation priorities within the PSDP will be derived.

The paper is organised as follows: Section 1 gives a brief introduction of the paper by describing and discussing the main objective of the paper. Section 2 reviews the literature relevant to the topic of the paper. Section 3 gives the framework of analysis of determinants of the TFP and the relationship between infrastructure and growth. This section also discusses the results of the two analyses. Final section concludes the paper and gives some policy recommendations.

2. LITERATURE REVIEW

Economists have been trying to measure the link between economic growth and infrastructure stock since long. Mostly, their effort has been to measure the impact of the private and public capital stock on the economic growth in terms of monetary values

[Denison (1980); Barro (1998, 1989) and Barro and Sala-i-Martin (1995)]. These approaches have been criticised vastly and their findings have mostly been found to be unreliable [Romp and Haan (2005); Straub (2008) and Straub and Terada-Hagiwara (2011)]. Because these studies have focused their analyses using the infrastructure variable at the aggregated level and it is hard to see impact on economic growth for the individual infrastructure stock. Aschauer (1989) initiated the empirical literature relating individual infrastructure stock to economic growth (productivity). He estimated that the productivity elasticity in relation to the public capital in the United States was 0.24 for the "core" infrastructure (i.e., roads and highways, airports, gas and electrical and gas facilities, mass transportation, sewers and water).

Recently, Straub and Terada-Hagiwara (2011) presents the state of infrastructure in developing Asian countries. They apply two distinct approaches (growth regressions and growth accounting) to analyse the link between infrastructure, growth, and productivity. Their paper concludes that the infrastructure stocks in developing Asia have been growing at a significant pace. However the findings show that their levels remain well below the corresponding world averages both in terms of quality and quantity. There seems to be a positive impact on the economic growth due to the accumulation of infrastructure stock (in electricity, telecommunications, transport, and water supply) as a massive build up of these stocks was needed but may be beyond the financial reach of many governments. Their analysis also give cross country estimations which shows that for most of infrastructure indicators, the growth rate of stocks has a positive and significant impact on per capita GDP average growth rate. Further, they have found on the basis of growth accounting exercise, a positive and significant effects of infrastructure variables on total factor productivity (TFP) growth.

In another paper, Straub (2008) did a survey of studies on the infrastructure stock and economic growth on developing countries in which energy, transport, telecommunication, water and sanitation are considered. There are two main set of issues that the survey covers. The first one is the linkages between infrastructure and economic growth at the economy-wide, regional and sectoral level. The second deals with the composition, sequencing and efficiency of alternative infrastructure investments which include arbitrage between new investments and maintenance expenditures, and public versus private investment. The survey sustains a number of conclusions which lead to potential research areas and need for associated data development; which can be organised in three related parts, relating to macroeconomic, microeconomic and economic geography aspects. Further he conclude that in terms of data development, the main effort should be concentrated in the microeconomic part, through a strategy to gather data from both household and firm-level survey on aspects including access, quality and costs of services. Indicators, aggregated at different levels, could then be used both in macro-level and economic geography types of estimations.

In most of the literature on infrastructure and economic growth, development of energy has always been considered critical for economic growth and social development [Isaksson (2010)]. Because as economies develop, energy consumption grows more or less in parallel, and adequate and affordable energy supply is needed to meet the demands of industry, commerce and domestic users and to enable the movement of people and goods [United Nations (2005)]. These studies find that energy is closely linked to poverty reduction because it is central to practically all aspects of the core conditions of poverty—such as poor health, lack of access to water, sanitation, and education. Enhancing access to energy services also reduces poverty and enables economic growth in a sustainable manner. This is a major challenge that countries must address in order to achieve the MDGs [United Nations (2005); Fan (2004)].

The Paris Declaration and the Programme of Action of the Second United Nations Conference on the least developed countries noted that the deterioration in physical infrastructure in the 1980s in these countries impaired their ability to resume growth and development. It also recognised that urban infrastructure had not kept pace with urbanisation, while rural infrastructure development suffered from a lack of institutional capacity and absence of decentralisation. In another study, Agénor and Blanca (2006) provide an overview of the various channels through which public infrastructure development may affect growth. In addition to the conventional productivity, complementarity and crowding out affects which is emphasised in the literature; the impact of developing infrastructure on the investment adjustment cost like durability of private capital, and production of health and education services are also highlighted.

Teles and Mussolini (2010) analyses the relationship between infrastructure and total factor productivity (TFP) in the four major Latin American economies: Argentina, Brazil, Chile and Mexico. They hypothesise that an increase in infrastructure has an indirect effect on long-term economic growth by raising productivity. To assess this theory, they use the traditional Johansen methodology for testing the cointegration between TFP and physical measures of infrastructure stock, such as energy, roads, and telephones. They then apply the Lütkepohl, Saikkonen, and Trenkler Test, which considers a possible level shift in the series and has better small sample properties, to the same data set and compare the two tests. Their results do not support a robust long-term relationship between the series and find strong evidence that cuts in infrastructure investment in some Latin American countries were the main reason for the fall in TFP during the 1970s and 1980s.

Canning and Pedroni (2004) investigated the long run consequences of infrastructure provision on per capita in a panel data of countries from 1950 to 1992. Their paper develop a simple panel based tests which enable them to isolate the sign and direction of long run effect of infrastructure on income in a manner that is robust to the presence of unknown heterogeneous short run causal relationships. The results show clear evidence that in majority of the cases the development of infrastructure induces long run growth effects. But a great deal of variation has also been seen in the results across individual countries. When the countries are taken as a whole, the results demonstrate that telephones, electricity generating capacity and paved roads are provided at close to the growth maximising level on average. But they are under-supplied in some countries and over-supplied in others. These results also help to explain why cross section and time series studies have in the past found contradictory results regarding a causal link between infrastructure provision and long run growth.

3. THEORETICAL FRAMEWORK AND EMPIRICAL RESULTS

As seen in the last section, most of the literature on economic growth measures the impact of the infrastructure through the standard production function where factors are gross complements, an increase in the stock of infrastructure capital would have a direct, increasing effect on the productivity of the other factors. These approaches measure the impact of infrastructure capital in terms of some estimates of output elasticity. However, recent studies point out a number of weaknesses in the methodology and estimation of these approaches on measuring the impact of infrastructure capital on economic growth. See for example Straub (2011); Romp and Haan (2005); and Bom and Ligthart (2008). The authors point out a number of weaknesses in the econometric analysis by the earlier studies. These weaknesses include the presence of likely potential reverse causality between output and infrastructure investment, which can generate an upward bias in the estimated coefficients. Taking these concerns into account, these authors find out that the output elasticities of public capital are between 0.1 and 0.2. Similarly, Calderón, *et al.* (2009) estimate the output elasticity of public infrastructure to be between 0.07 and 0.10.

This paper uses a different methodology to measure the impact of the physical infrastructure development on economic growth in Pakistan, as developed by the Straub and Terada-Hagiwara (2011). In this approach, the relationship between the infrastructure and growth is quantified by indicators of physical availability of infrastructure rather than the total public capital stock (in constant prices) in infrastructure. This approach also has the merit that it enables identification of the differential impact of various types of infrastructure on growth.

The analysis of the paper is divided into two parts. In the first part, we present the determinants of TFP using the growth accounting framework. In the second part, we present the growth regression analysis to measure the impact of individual infrastructure variables on economic growth.

(a) Determinants of Total Factor Productivity

In this section, we used growth accounting analysis to find out the determinants of TFP. Specifically, in this part, we try to find out the impact of public capital stock on TFP along with other exogenous variable. For this, we ran a regression of the form

$$GTFP_t = \alpha_{0t} + \alpha_{1t}GPKS_t + \alpha_{it}Z_{it} + e_t; \qquad i = 2,3,\dots,n$$

where *GTFP* is the growth rate of total factor productivity, *GPKS* is the growth rate of the public capital stock and Z_{it} is the vector of other exogenous variables. Three most important determinants of the total factor productivity, other than public capital stock, that can be identified from the literature are the human capital stock, foreign direct investment and the trade openness of a country. The growth rate of the TFP is calculated by taking the elasticities of the labour, capital stock and the land from the paper of Ahmed and Bukhari (2007).[1] The analysis period of this paper is almost same as the analysis period of this paper. Data for the GPKS construction requires long term series data and is a time-consuming task. Fortunately, the data base of the Social Policy and

[1]*Y* is the gross domestic product, *A* is a measure of total factor productivity, *K* is the capital stock, *N* is the total labour force and *L* is the land. From this production function, we calculated TFP by the Solow's residual equation, as

$$\frac{\Delta A}{A} = \frac{\Delta Y}{Y} - \alpha\frac{\Delta K}{K} - \beta\frac{\Delta N}{N} - (1-\alpha-\beta)\frac{\Delta L}{L}$$

For more details on the methodology, see the paper of Ahmed and Bukhari (2007).

Development Centre (SPDC) Integrated Social Policy and Macroeconomic Planning Model for Pakistan contains such an index, which has been constructed from 1972-73 to 2007-08 at constant prices of 1999-2000. This index has been made available to us by SPDC. From 2007-08 onwards, the series has been extended using the methodology of the SPDC's model. For other variables data is collected from the Annual Reports of the State Bank of Pakistan and Annuals Reports of the SPDC.

The results of the regression on determinants of TFP are given below:

$$GTFP = -1.0525 + 0.785GMYS + 0.317GPKS + 0.012GFDI + 0.048GOPENNESS$$

(–2.391)** (4.328)* (3.665)* (2.783)* (1.689)***

Adjusted-R^2 = 0.636, DW-Stat = 2.539

F-statistic = 11.490 (0.000)

In this regression, *GMYS* is the growth rate of the mean years of schooling taken as a proxy for human capital stock, *GFDI* is the growth rate of foreign direct investment and *GOPENNESS* is the growth rate of the trade openness. The results of the regression are very much according to the expectations. As can be seen from the results, the human capital development has the largest impact on the *TFP* growth. After it growth in the public capital stock has the largest impact on growth of *TFP*. Other two variables, *GFDI* and *GOPENNESS*, also impact growth in *TFP* positively and significantly but their magnitude is relatively small compare to *GMYS* and *GPKS*. Overall, the regression is a good fit and gives reasonable results.

(b) Growth Regression Analysis

As we saw in the last section that public capital stock has a significant positive impact on TFP. In this section, we will see how the individual physical infrastructure stock has an impact on economic growth. For this we used the following growth regression technique:

$$g_t = \beta_{0t} + \beta_{it}Z_{it} + \beta_{jt}K_{jt} + e_t$$
$$\text{while } i = 1,2,\dots,m \ \&\ j = 1,2,\dots,n$$

where g_t is the growth rate of real per capita GDP, Z_t is a vector of control variables and K_t is a vector of physical infrastructure variables. To control the structure of the economy we used the following variables: agriculture growth rate, nominal interest rate, and the mean years of schooling. On the other hand, the following indicators of physical availability of infrastructure have been used in the analysis:

- per capita electricity generation, adjusted for transmission losses (in Gwh),
- per capita availability of water for agriculture (in MAF), including water from tubewells,
- length of roads (in Kms), and
- telephone lines (including mobile phones) per 100 people.

Data on the above indicators has been obtained for the period, 1975-76 to 2010-11, from the *Pakistan Economic Survey* and the *World Bank Development Indicators* data base.

Results of the econometric analysis of the impact of growth of different types of infrastructure on the growth rate of real per capita GDP are given in Table 2. Initially, we ran regression only on the exogenous variables, which are agricultural growth, nominal interest rate and mean years of schooling. Then along with these exogenous variables each infrastructure indicator is introduced separately, in Equations (2) to (5) respectively. Thereafter, different infrastructure indicators are added sequentially in Equations (6) to (8).

The results of the regressions with separate indicators indicate the high level of significance of the electricity generation indicator. The telecommunications and water availability indicators are also significant at the 5 and 10 percent level of significance. The surprising result is the complete lack of significance of the indicator of access to roads and highways. This is the first indication that the country has perhaps been over-investing in the development of the road network, especially highways.[2] As expected, the exogenous variables, especially agricultural growth, are significant in most regressions. The other two exogenous variables are also highly significant.

The results do not alter when all infrastructure indicators are introduced simultaneously into the regression analysis. The significance of the electricity generation indicator remains unchanged, highlighting the robustness of the relationship between availability of power and growth. The elasticity of per capita income growth with respect to growth in electricity is about 0.16. This is close to the elasticity of 0.20 estimated by Straub and Hagiwara (2010) for a cross-section of Asian countries. From the analysis, it is clear that part of the reason for the decline in GDP growth rate in the last few years is clearly due to the failure in expanding power generation capacity.

The water availability and telecommunications variables also remain significant at a high level of significance. The access to roads variable remains insignificant when all infrastructure variables are introduced simultaneously in the growth regressions. Overall, the results clearly demonstrate a clear positive and highly significant differential impact of various types of infrastructure on growth. The table also presents the results of the Wu-Hausman test of endogeneity. Its p-value indicates that there is no problem of endogeneity in the regression models.

From the model, we have estimated the capital cost of electricity generation per 100 MW from a sample of the recent vintages of plants. The cost is approximately $950 million per 100 MW. Given the coefficient of electricity generation capacity in the growth regressions the implied incremental capital-output ratio is only 0.57. This indicates the high returns today to investment in the power sector.

4. CONCLUSION AND POLICY RECOMMENDATIONS

Physical Infrastructure stocks in Pakistan since the last two decades have been growing at a low pace and this is the main reason of low economic growth since the last four years. The paper reviewed the state of infrastructure development in Pakistan and performed two types of analyses. In the first analysis, it tried to find out the impact of different indicators on TFP, specifically that of the public infrastructure stock and, in

[2]According to the *Global Competitiveness Report, 2010-11,* Pakistan has a higher ranking in Quality of Roads than countries like Iran, Egypt, Indonesia, India and Bangladesh, although Pakistan still has not reached desirable levels of road density.

Table 2

Results of Regressions Analysis on Infrastructure and Growth[a]
(Dependent Variable is Growth Rate of Real Per Capita GDP)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	**(8)**
Constant	4.024*	2.603***	4.214*	1.871	3.938*	2.946**	**1.543**	1.403
	(2.720)	(1.879)	(2.971)	(1.328)	(2.602)	(2.447)	**(1.274)**	(1.124)
Agriculture Growth Rate	0.294*	0.284*	0.303*	0.235*	0.294*	0.320*	**0.287***	0.286*
	(4.630)	(4.933)	(4.971)	(4.227)	(4.554)	(6.357)	**(6.088)**	(5.993)
Nominal Interest Rate (%)	–0.325*	–0.240***	–0.326*	–0.192***	–0.327*	–0.252*	**–0.163*****	–0.164***
	(–2.876)	(–2.275)	(–3.018)	(–1.856)	(–2.854)	(–2.746)	**(–1.816)**	(–1.811)
Growth Rate of Mean Years of Schooling	0.437*	0.413*	0.431*	0.554*	0.440*	0.304**	**0.352***	0.358*
	(2.607)	(2.796)	(2.685)	(3.887)	(2.588)	(2.530)	**(3.183)**	(3.185)
Growth Rate of Electricity Generation Per Capita	–	0.120*	–	–	–	0.161*	**0.160***	0.157*
		(3.283)				(5.193)	**(5.716)**	(5.456)
Growth Rate of Per Capita Water Availability	–	–	0.174***	–	–	0.325*	**0.327***	0.327*
			(1.954)			(4.592)	**(5.099)**	(5.030)
Growth Rate of Per Capita Availability of Telephones and Mobiles	–	–	–	0.020**	–	–	**0.019***	0.020*
				(2.314)			**(2.684)**	(2.686)
Growth Rate of Length of Roads	–	–	–	–	0.032	–	**–**	0.035
					(0.427)			(0.589)
Adjusted-R^2	0.514	0.624	0.556	0.664	0.501	0.726	**0.774**	0.769
F-statistics	12.650*	11.971*	11.333*	14.099*	9.275*	16.426*	**18.122***	15.530*
DW-Stat	2.297	2.372	2.449	2.032	2.292	2.067	**2.646**	2.552
SC-Value	3.709	3.591	3.689	3.476	3.807	3.367	**3.238**	3.325
Wu-Hausman test, p-value						0.185	**0.587**	0.529

[a] *Note*: *, **, *** indicate that the coefficients are significant at the 1 percent, 5 percent and 10 percent level of significance. Values in parentheses are the t-ratios. SC-value is the Schwarz criterion value. SC-Value is the Schwartz Criterion value. We perform the Wu-Hausman test of endogeneity and each equation passed the test. The analysis period is from 1975-76 to 2010-11.

Table 2

second analysis, it tried to find out the impact of the physical infrastructure stock (electricity generation, telecommunications, water availability and access to roads and highways) on real per capita GDP. Both these analyses clearly demonstrate that infrastructure matters from the viewpoint of growth and TFP. Individual and combined results, from the growth regression, show that investments in power generation, telecommunications and in enhancing the availability of water for agriculture have significant effects on growth. However, in the Pakistani setting, development outlays on expanding/upgrading the road network do not seem to confer significant visible benefits. Within the PSDP, the sector actually receiving the largest allocation currently in the area of infrastructure development is communications (mostly highways). There is a case for changing this priority and diverting resources away from communications to water and power to achieve a bigger impact on GDP growth within the given size of PSDP. Also, results of the analysis do not have implications on priorities within the communications sector. For example, it may be that investment in railways sector and expansion of the road network may have higher returns than development outlays on Motorways and Expressways.

Further, as can be seen from results of both analyses, infrastructure stock accumulation has a positive impact on economic growth and a massive buildup of infrastructure stock in electricity, telecommunication, transport, and water supply is needed for it to have a positive impact on economic growth. Moreover, demand for infrastructure services is expected to soar in cities due to rapid urbanisation. In order to keep cities competitive, investments in infrastructure need to be designed to take account of congestion, environmental degradation, and other impediments to productivity that are associated with urban agglomeration. Another key question refers to sequencing. Which type of infrastructure is more effective in supporting growth and should be prioritised? Clearly, the results show that investment in electricity generation capacity should be the most important priority of the Public Sector Development Programme (PSDP). Currently, the total outlay through the budgetary PSDP and self-financing of power investments adds up to 0.65 percent of the GDP. This will have to be increased to above 1.5 percent of the GDP if the problem of shortage of electricity is to be addressed on a priority basis so as to raise the growth rate of the economy.

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