

## Infrastructure Investment and Its Impact on Economic Growth: The Case of Bangladesh

Musharrat Azam<sup>1</sup>, Sabrina Shareef Badhan<sup>2</sup>

<sup>1</sup>(Lecturer, Department of Economics, Bangladesh University of Professionals (BUP), Bangladesh)

<sup>2</sup>(Senior Research Associate, Policy Research Institute, Bangladesh)

Corresponding Author: Musharrat Azam

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**Abstract:** Infrastructure development is vital for a nation's growth. Inadequate investment in physical infrastructure and human capital is likely to jeopardize a nation's development prospects. Bangladesh has been maintaining about 7% growth rate and in order to keep up with its rising growth trends, the infrastructure investment in Bangladesh needs to go up and also must be efficiently handled. This paper analyzes the current infrastructure situation in Bangladesh and shows how investment in various sectors can accelerate the economic growth. The model used in the paper is a Partial Adjustment Model where the short run and long run infrastructure elasticities of economic growth have been calculated. The findings suggest that investment in health, education and telecom would yield positive outcomes for Bangladesh economy in the short run. Although investment in electricity do not bring about a positive elasticity in the short run, it is expected to render its effectiveness in the long run. The cost of increasing electricity generation capacity has been identified as one of the reasons for its negative impact in the short run. In order to grow into a middle-income country, Bangladesh still needs to invest heavily in infrastructure and thereby improve the living standards of its citizens.

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### I. Introduction

The notion that investment in infrastructure could have an impact on a region's rate of productivity and therefore its economic growth did not get attention until the late 1980's. This perception was altered by the work of Aschauer in 1989 when he published a series of papers that investigated the relationship between infrastructure investment and productivity for the United States and other developed nations<sup>13</sup>. Aschauer found a strong positive correlation between productivity and public capital for core infrastructure that consists of highways, mass transit, airports, electrical and gas facilities, water, sewers, police and fire stations and hospitals<sup>6</sup>. The productivity elasticity for core infrastructure from this study was estimated to be 0.24 and highly significant.

Infrastructure plays a pertinent role towards economic growth. There are different approaches to how infrastructure achieves this. Infrastructure such as energy, electricity, water, roads and telephone serve as direct input to production process. Improvement of these utilities reduce the cost of production and transaction, increase productivity and returns to scale. These lower costs and higher returns induce domestic private and foreign investment in the economy. Lee and Anas (1992) and Hasnath (1993) found that aggregate infrastructure also increased productivity of other factors of production and augmented the rate of technological innovation. Human capital infrastructure for example education and health service increase worker productivity and raise wages. Furthermore, infrastructure projects raise income through direct employment creation in construction and operations<sup>15</sup>.

Bangladesh had experienced an average GDP growth rate of 5.76% from 1994 until 2017 with a record GDP growth rate of 7.28% in fiscal year 2016-2017. This growth rate had been the key to graduating to a low middle-income status from a low-income nation. The 7<sup>th</sup> year plan of the government of Bangladesh which encompasses the years 2015-2020 aims a GDP growth rate of 8% by 2020. A vital way of achieving this is to increase the rate of investment as a share of GDP from 28.9% in 2015 to 34.4% by the end of the plan in fiscal year 2020<sup>7</sup>. Countries such as India, China and other emerging economies in East Asia achieved substantial growth rate through considerable investment as a share of GDP. Thus, the targeted growth rate of the Bangladesh government can only be achieved through an increase in the share of investment as a part of GDP. This increase in investment should originate from both the public and private sector. Then again, a very important factor of obtaining high GDP growth rates is efficiency of government investment especially in the public sector. Maximum benefits can be reaped from the public investments if they are efficient. The efficiency level in the case of investment in public sector such as public infrastructure hence plays a crucial role in accomplishing high growth rates.

The aim of this study is to examine the relationship between investment in various infrastructure and economic growth rate of Bangladesh. Particularly, the goal is to analyze the role infrastructure investment plays on the economic growth of Bangladesh. In order to achieve this objective, this paper determines the short run and long run relationship between infrastructure investment and GDP growth in Bangladesh. The result of this study will help to get an idea of the extent of investment in infrastructure required to achieve targeted GDP growth rate.

The structure of this paper is organized as follows. Section II discusses existing literature that investigates the impact infrastructure has on economic growth. Section III gives an extensive overview of the scenario of infrastructure in Bangladesh. Section IV summarizes in brief existing study of this sort conducted on Bangladesh. Section V describes the methodology used in this paper. Section VI provides the findings and recommendations while Section VII ends with the conclusion.

## **II. Literature Review**

### **Impact of Infrastructure on Economic Growth: Evidence from countries across the world**

Subsequently following the work of Aschauer, there have been several studies that analyzed the impact of investment in infrastructure on economic growth. Bougheas *et al.*, 1999 regressed GDP per capita growth on telecommunication infrastructure represented by telephone lines and transport infrastructure represented by paved roads.<sup>10</sup> This cross-country regression was conducted on a pool of about 119 countries with data obtained from 1970 to 1985 from the World Bank. Results from this study indicated a positive correlation between the infrastructure measures and growth of per capita GDP. The output elasticity for transport infrastructure varies across countries ranging from 0.001 for Finland to 0.183 for Austria. The estimated elasticities for telecommunication infrastructure are much smaller than transport infrastructure with occasionally being one tenth of the estimate of transport infrastructure.

Another study by Calderon and Servén, 2010 used a simple equation to relate GDP per capita growth to quantity and quality of infrastructure<sup>11</sup>. To develop this model the researchers used macroeconomic panel data spanning from 1960 to 2005 encompassing 136 countries. The infrastructure measures used in this study comprised of telecom, electric power and total roads. The model was estimated using a GMM-IV estimator method and resulted in a positive and significant coefficient between quantity and quality of infrastructure and economic growth. This led to the conclusion that both infrastructure quantity and quality leads to economic growth. The estimated relationship was also segregated across different regions. The largest contribution of infrastructure to GDP growth was in East Asia during this period where increased infrastructure increased growth rate by 1.93 percentage points per year. Of this 1.32 percentage was due to enlarged infrastructure stock and 0.61 percentage was due to enhanced quality. In the middle-income countries infrastructure development contributed significantly towards economic growth with an average of 2.29 percent per annum.

Apart from examining the impact of infrastructure stock on output, another determinant of infrastructure that leads to economic growth is the investment or expenditure on infrastructure as a share of GDP. This is what Sanchez-Robles, 1998 has done in her study where two samples of countries are taken with the first one encompassing 57 countries across five continents and the second one having 19 countries from Latin America<sup>29</sup>. Infrastructure expenditure as a share of GDP in this study included expenditure on road transport, other transport and communication and fuel and energy. The coefficient of expenditure in infrastructure as a share of GDP for the larger sample turned out to be negative and insignificant whereas the coefficient for the Latin American countries is positive and significant. However, the coefficient for infrastructure measured in physical units resulted in a positive and significant coefficient for both the samples reinforcing the fact that the stock of infrastructure leads to economic growth. One interesting theory deduced from the negative coefficient is that when public capital has reached saturation point in developed nations, the effect of marginal public capital on output growth might be negligible. On the other hand, for low and middle-income countries where the level of infrastructure is substantially lower, the marginal infrastructure expenditure does have a positive impact on economic output.

The impact of public investment in infrastructure was also examined by Easterly and Rebelo, 1993 by using a cross section data of about 100 countries for the period 1970-1988<sup>12</sup>. Sectors for public investment in this study included education, health, urban and housing infrastructure, transport and communication among others. The transport and communication investment are significantly positively correlated to per capita GDP growth with a coefficient of 2 which is considerably high. Public investment in education also contributed towards the economic growth rate. This study concluded that public investment in transport and communication in developing nations results in supernormal returns in economic output.

A simultaneous model was developed by Roller *et al.*, 1996 to estimate the effect of telecommunication infrastructure investment on economic growth<sup>28</sup>. The model used data for 35 countries of which 21 are OECD countries and 14 are developing or newly industrialized nations. The data spans over a twenty-year period from 1970 to 1990. The study results indicated that a 10% investment in telecommunication investment in one year

increases the telecommunication line penetration rate by 0.2% in the consecutive year. Consequently, this increase in penetration rate generates significant aggregate economic growth. A 1% increase in the penetration rate increases the GDP growth rate on average by 0.55%.

These literatures deliberated above provides evidence that infrastructure and investment in infrastructure has a positive impact towards the economic growth of a nation and this impact varies from trivial to immense depending on the economic status of the nation and the type of infrastructure.

#### **Present scenario of various infrastructure in Bangladesh and its impact**

##### **Rail:**

Tsuneyuki Sakai, an ADB senior transport specialist very recently said in a meeting, “Railways in Bangladesh potentially offer a cheaper, safer, and more fuel-efficient means of transport of goods and passengers than roads, but have been held back by lack of investment and aging and unreliable rolling stock. The ADB Railway Rolling Stock Operations Improvement Project will boost the operational performance of Bangladesh Railway by introducing new technology, equipment, and processes that will be cleaner and more efficient, cutting carbon dioxide emissions.”

Historically in Bangladesh, railways were the only means of transportation by which goods travelled to and from. However, its market share has dropped because of inadequate investment in railway infrastructure over a long period of time, according to the statement made by ADB transport specialist. Under its five-year plan for fiscal years 2016-2020, the government has placed new plans on railway development, setting targets to increase the market share to 15 percent in freight transport and 10 percent in passenger movements by 2020. Bangladesh Railway has also been operating at a loss, its operating costs are almost double compared to its revenue. Under the railway reform supported by ADB, the government has taken steps to boost revenue by raising the level of passenger and freight tariffs that have remained unchanged for a prolonged period. Starting with a railway improvement programme in 2006, ADB has provided four loans to the government for railway development totalling \$2.81 billion. A loan taken in 2015 is also underway and the work should be completed by 2020. It will procure 40 broad gauge locomotives, 125 luggage vans, and 1,000 wagons for freight trains for use on major lines. The project will introduce investment plans for various maintenance facilities, establish training programmes for the drivers, and run the enterprise-wide IT system<sup>8</sup>.

According to the CIA World Factbook, Bangladesh is served by a network of 201,182 kilometers of primary and secondary roads, but only around 10 percent of them are paved. In June 1998 the huge US\$1 billion Jamuna Bridge was completed, becoming the 12th-longest bridge in the world. This project made an important contribution to the development of the country's transportation network and significantly improved the quality and speed of passenger and freight transportation, thereby reducing the burden of goods transportation via railroads alone.

##### **Telecom:**

This is one of the sectors of infrastructure that has received very minimal attention from policy makers and therefore, not much has been done to improve the telecommunication industry in Bangladesh. A report jointly produced by BCAS and World Bank discussed the limitations of telecom services in Bangladesh, reporting: the telephone density of 0.39 lines per 100 people is one of the world's lowest (India: 1.0, Nepal: 0.5, Pakistan: 2.1, Sri Lanka: 1.0, Thailand: 2.5); the waiting time for a connection is more than 10 years and the installation charge of US\$ 450 for a new line is one of the highest in the world (e.g. Pakistan US\$ 90, India US\$ 60); the charge for calling the UK, US\$ 1.50/min, is about six times higher than the charge for calling Bangladesh from the UK; on average, only 2 of 10 calls are successfully completed; the complaint rate averages 50 complaints per 100 lines per year, clearly indicating the poor quality of services.

Bayes, 2001 states that the situation of underdevelopment in poverty stricken lands of Bangladesh won't improve unless there's improvement in both human and physical basic infrastructure<sup>2</sup>. He discusses the concept of Grameen Bank introducing cellular mobile phones (VPPs) in rural areas to be operated under its micro-credit programs. Among its many benefits, VPPs have given better consumer surplus and a much faster, safer and easier mode of communication for the poor. One major benefit of VPPs was seen in July–September 1998, when Bangladesh was hit by a severe flood. Local government officials informed that the availability of VPPs enabled them to take control of the situation quickly. In a few of the sample villages, it was reported that the law and order situation had improved because of the availability of VPPs. Overseas communication also became cheaper, people stayed more connected with business partners or family members. Villagers can now contact clinics, doctors or ambulances rapidly, even at night, which was not possible prior to the introduction of VPPs. Various studies in the context of micro-credit programs in Bangladesh argue that there have been substantial positive developments in the empowerment of women (e.g. Amin et al., 1998, pp. 36). Mobile phones have increased the scope for better knowledge creation, made women more mobile within and outside their villages, increased scope for business, increased income and introduced opportunities for coping with natural calamities and enact law enforcement. Ms. Farhana Zamil and Miraj Hossen, 2012 discussed about the

prospects and challenges of telecommunication sector where they talked about the governmental SIM tax, corporate tax and the competition in the market<sup>33</sup>. According to the number of subscribers and profitability Grameen phone Ltd is in the top position among all six operators. At the end of March 2011, Grameenphone has the highest subscriber, followed by Banglalink, Robi, Airtell, Citycell and Teletalk. Mobile phone sector is the top sector for foreign investment and source of government revenues in Bangladesh. But the position of Bangladesh in attracting foreign investment is not up to the mark although Bangladesh is one of the top ten countries in the world for investment in this sector. According to a report of world famous Auditing Institution Deloitte, "In developing country, if using of mobile phone increase by 10%, government revenue will increase by 1.2% in a year." In their article, Zamil and Hossen, 2012 point out the challenges of telecommunication sector although the revenue from mobile phones is increasing every year<sup>33</sup>. High competition, poor economic background, instable political situation, high rate of corporate tax, SIM tax and import tax on technology are all impediments to the growth of this sector. Improvement in telecommunication will engender benefits like job creation and reduced unemployment, higher government revenues, develop corporate culture and make it more competitive and so on. Therefore, the government should revise the tax policy on phone services as suggested in the paper. Study shows that if the tax on SIM and imported equipments is totally reduced, subscribers will increase by a great extent and business will increase from 30% to 56%.

### **Education:**

In a labour force survey done in 2010, it shows that some 40% of the workforce has no education; some 23% have only up to primary education; and less than 4% have tertiary education. Labor force training programs are not sufficient either. Sadiq Ahmed, 2012 he stated the requirement for further increased government spending in the education sector and rural infrastructure in order to help build the human capital and opportunities for the poor besides limited triumph of land redistribution measures by the government under the threshold of corruption<sup>4</sup>. Matin, 2014 also highlights the poor-quality education through a UNESCAP Survey cited in his work<sup>23</sup>. In a report by the International Monetary Fund (2017) addressing the poverty conditions in Bangladesh, it recognizes the requirement of increased government spending in the education sector. This will equip the poor to get better and higher paying employment, which, in turn, would help the growth in GDP. Wodon, 1999 also states, through his empirical analysis, that households that have more educated members have higher income and thus lower income gap with richer households, compared to other households with lower number of educated family members<sup>32</sup>. Rahman and Taposh, n.d. find that households with higher accumulation of wealth end up having better access to education and thus it is their future generation that earn more than that of low-income households<sup>26</sup>. They also pointed out the fact that the communities in the urban societies have access to more opportunities than rural sectors and thus they lag behind in both private and public institutions. Jose and Jong, 2002 as well as Kevin, 2000 highlight that countries that have low literacy levels also have lower economic growth than countries that have higher literacy rates. High drop-out rates, low quality education in the rural sector thus define a poor education system in Bangladesh overall and therefore requires more attention from the government to help improve the quality of education.

### **Electricity and energy consumption:**

Golam Ahamad and Nazrul Islam, 2011 examined the causal relationship between per capita electricity consumption and per capita GDP of Bangladesh from 1971-2008<sup>3</sup>. They found out a unidirectional short run relationship running from per capita electricity consumption to per GDP capita whereas in the long run, GDP affects electricity consumption and vice versa. This finding has immense implications for Bangladesh economy because it implies investment in electricity sector in the short run will engender economic benefits for both the short and the long run. However, the findings from Pallab Mazumder and Achla Marathe, 2006 shows a relationship that runs from per capita GDP to per capita electricity consumption and not the other way round<sup>24</sup>. They have concluded that per capita electricity consumption does not lead to an increase in per capita GDP in Bangladesh. Asaduzzaman and Billah, 2006 explored the historical relationship between energy consumption and economic growth for Bangladesh<sup>5</sup>. They reported that the level of energy use had been positively related to the level of growth and higher level of development was known to entail higher level of energy use. For instance, Shahidur and Hussain, 2012 discusses the idea of Nieuwenhout et al. 1998 where they found that electricity improves household lighting, thereby increasing study hours (Barkat et al. 2002; World Bank 2002a), and providing more hours available for household chores as well as for income generating activities (World Bank 2002b)<sup>25</sup>. Their article also discusses how switching to more efficient devices causes significant time-saving and efficiency gains. The saved time can be employed to productive purpose for income growth<sup>32</sup>.

CPD 2011 report states that Bangladesh has remained one of the least per capita electricity consuming economies in the world which definitely has an impact on its growth and investment prospects. Electricity demand in the country is increasing day by day because of expansion in economic activities<sup>5</sup>. But there's a gap between electricity creation and electricity consumption due to a shortage in fuel supply, decrease in generation

capacity by aged power plants, lack of timely maintenance and overhauling works for old plants. Only 20% of the population has access to electricity with a per capita availability of 120kWh per annum. Problems in Bangladesh's electric power sector include high system losses, delays in completion of new plants, low plant efficiencies, erratic power supply, electricity theft, blackouts, and shortages of funds for power plant maintenance<sup>24</sup>. A survey report on Bangladesh shows that power outages result in a loss of industrial output worth \$1 billion a year which reduces the GDP growth by about half a percentage point. The demand for electricity is growing at a rate of 10% per year (USAID, 2003) without any investment to meet this increasing demand. Although government has taken an initiative to generate additional 11,698 MW of electricity by 2015, but the current lack of electricity creation has affected the economic activities and growth prospects in Bangladesh, mainly in the form of lesser investment and lack of employment opportunities<sup>3</sup>. For example, average electricity generation needs to go up at the rate of 12.5–14.5% per annum to match with the projected GDP growth target of 8.1% under the five year plan period of 2011–2015 (CPD, 2010).

### **Health:**

According to a WHO report on Bangladesh's health service, there have been some recent changes that led to better functioning of the healthcare facilities. For example, regular and timely publications of health bulletins and year books, modernization of the data collection and storage system, publication of the Health Information System (HIS) assessment report using Health Metric Network (HMN) assessment tools are some of the initiatives the government has taken. Besides the improvement in organizational strategies, considerable functional improvement has also been made in health libraries with capacity building of health librarians and application of ICT tools in various areas. A good number of health professionals have been exposed to acquiring international knowledge and expertise. Communication between health sectors and other information collecting agencies is very poor. For example, at present three major MIS i.e. health, family planning and nutrition, are functioning under the Ministry of Health and Family Welfare (MoHFW) with little or almost no coordination between them. There is also no established communication of MOHFW with other agencies/departments like the Bangladesh Bureau of Statistics (BBS) which is engaged in collection and dissemination of health information (WHO, Bangladesh). Currently, WHO is working in Bangladesh in order to bridge the gap between various organizations, gather and secure information, train health professionals regionally and abroad among other operations which would help to bring about positive changes in the health sector of Bangladesh if implemented correctly. Currently, Bangladesh is interested in exploring how health IT can improve health care quality by enabling more effective population health management and patient-centered care delivery and coordination<sup>31</sup>. Health IT systems can provide a longitudinal view of the patient's health and history, which is important for patients with chronic or complex health issues. Hence, the Government is now actively seeking health IT solutions and thereby support better population management and patient-centered care delivery and coordination.

### **Similar studies in the context of Bangladesh**

There have been just a handful of literature that studied the role of infrastructure and infrastructure investment on the economic growth of Bangladesh. Khandker and Samad, 2018 made the assertion that infrastructure development generates structural transformation. They basically state in their study through an in-depth review that infrastructure development in Bangladesh has allowed this nation to transform from a traditional, low productivity, and mostly agricultural economy to a modern economic system that includes industrial, manufacturing, and service sectors, with high productivity and fast growing technology<sup>18,20</sup>.

Khandker et al., 2012 analyzed a cross sectional data of 20,900 rural households in Bangladesh for the year 2005. This study found that household electrification increased total household income by 21.2%. Rural electrification did not only increase farm income but non-farm income as well. This study also concluded the grid electrification in rural households contributed towards poverty reduction by some 1.5 percentage points per year<sup>21</sup>.

Another paper of Khandker and Koolwal., 2010 analyzed how infrastructure and credit expansion in rural Bangladesh contributed to household income growth and poverty reduction. This study used a large dataset covering a 10 year period from 1991 to 2001 of three household panel surveys<sup>19</sup>. The rural infrastructure that is taken into consideration is the percentage of village cultivable land irrigated, whether the village is within 500 meters of a paved road and the percentage of households in the village that have access to electricity. The effect of infrastructure on household income has been decomposed into two parts consisting of farm and non-farm income. Results in this paper indicate that a one percent increase in households with access to electricity has increased total per capita income by 0.8 percent. Alternatively, there has been a 33 percent increase in total per capita income due to access to a paved road. An interesting result that emerges from this study is that nonagricultural income or non-farm income rise concavely with an increase in village land irrigated whereas it has no significant impact on farm income. This implies that the non-farm income increases at a diminishing rate

with increase in irrigation and then eventually becomes negative at greater levels of irrigation. Furthermore, the results of this study suggest higher irrigation and electrification has lead to higher agricultural productivity and output.

### III. Methodology

All the data in this study have been taken from World Bank Database (2017). The data spans from 1990 to 2015.

This study uses the Partial Adjustment Model approach to estimate the elasticity of GDP per capita with respect to infrastructure stock and investment for Bangladesh. The choice of this model is to capture the short run and long run responses of economic output to changes in the infrastructure variables. A simple static model assumes instantaneous change in GDP to changes in various infrastructure components. Whereas the partial adjustment model takes into consideration that economic output does not respond immediately to changes in determinants but gradually converges to the long run equilibrium. This could be due to the fact that it takes a considerable amount of time to reap economic benefits from investment in infrastructure made today.

In this study the partial adjustment model will be a linear logarithmic model expressing GDP per capita as a function of investment in telecoms with private participation, government expenditure on education as a share of total government expenditure, access to electricity as a percentage of total population, health expenditure as a share of GDP and rail lines (in km). This goes according to economic theory and prior literature discussed above. The double log functional form serves the purpose of calculating elasticities.

Suppose the actual value of the GDP per capita is  $GDP_{pc_t}$  and  $GDP_{pc_t}^*$  is the desired or equilibrium level of GDP per capita which is not directly observable.

Then,  $\ln GDP_{pc_t}^* = \beta_1 + \beta_2 \ln telecom_t + \beta_3 \ln education_t + \beta_4 \ln electricity_t + \beta_5 \ln health_t + \beta_6 \ln rail_t + \mu_t$  (1)

Where  $\ln GDP_{pc_t}^*$  is the natural log of GDP per capita at time t,  $\beta_1$  is the intercept term,  $\ln telecom_t$  is the natural log of investment in telecoms with private participation at time t,  $\ln education_t$  is the natural log of government expenditure on education as a share of total government expenditure at time t,  $\ln electricity_t$  is the natural log of access to electricity as a percentage of total population at time t,  $\ln health_t$  is the natural log of health expenditure as a share of GDP,  $\ln rail_t$  is the natural log of rail lines (in km) at time t and  $\mu_t$  is the error term.

Under the assumption of partial adjustment model, the change in actual GDP per capita ( $\ln GDP_{pc} - \ln GDP_{pc_{t-1}}$ ) will be equal to a proportion of the desired change ( $\ln GDP_{pc}^* - \ln GDP_{pc_{t-1}}$ ) or

$\ln GDP_{pc} - \ln GDP_{pc_{t-1}} = \delta (\ln GDP_{pc}^* - \ln GDP_{pc_{t-1}})$  (2)

where  $\delta$  is the adjustment coefficient, which takes values from 0 to 1, and  $1/\delta$  denotes the speed of adjustment (Dimitrios and Hall, 2007).

Combining equations (1) and (2):

$\ln GDP_{pc} - \ln GDP_{pc_{t-1}} = \delta (\beta_1 + \beta_2 \ln telecom_t + \beta_3 \ln education_t + \beta_4 \ln electricity_t + \beta_5 \ln health_t + \beta_6 \ln rail_t + \mu_t - \ln GDP_{pc_{t-1}})$ ,

or,  $\ln GDP_{pc} = \delta \beta_1 + \delta \beta_2 \ln telecom_t + \delta \beta_3 \ln education_t + \delta \beta_4 \ln electricity_t + \delta \beta_5 \ln health_t + \delta \beta_6 \ln rail_t + \delta \mu_t - \delta \ln GDP_{pc_{t-1}} + \ln GDP_{pc_{t-1}}$ ,

So:  $\ln GDP_{pc} = \delta \beta_1 + \delta \beta_2 \ln telecom_t + \delta \beta_3 \ln education_t + \delta \beta_4 \ln electricity_t + \delta \beta_5 \ln health_t + \delta \beta_6 \ln rail_t + (1-\delta) \ln GDP_{pc_{t-1}} + \delta \mu_t$  (3)

Here  $\delta \beta_2$ ,  $\delta \beta_3$ ,  $\delta \beta_4$ ,  $\delta \beta_5$  and  $\delta \beta_6$  are short run telecom investment, education investment, access to electricity, health investment and rail line elasticities of GDP per capita respectively. The long run elasticities are obtained through dividing the short run elasticities by  $1-(1-\delta)$  or  $\delta$  (Pindyck and Rubinfeld, 1998). So:

Long run telecom investment elasticity =  $\delta \beta_2 / \{1-(1-\delta)\} = \beta_2$ , long run education investment elasticity =  $\delta \beta_3 / \{1-(1-\delta)\} = \beta_3$ , long run access to electricity elasticity =  $\delta \beta_4 / \{1-(1-\delta)\} = \beta_4$ , long run health investment elasticity =  $\delta \beta_5 / \{1-(1-\delta)\} = \beta_5$  and long run rail line elasticity =  $\delta \beta_6 / \{1-(1-\delta)\} = \beta_6$

Equation (3) can be consistently estimated using the Ordinary Least Squares (OLS) method. Elasticities attained from this model are assumed constant but this model is still preferred for its simplicity and straightforward interpretations and it generally outperforms models that are more complex (Amarawickrama and Hunt, 2008).

### IV. Results and Discussions

#### Model Output and Specification

The equation below shows the model output result with the parameter estimates.

$\log GDP_{pc} = -2.0192 + 0.00468 \log telecom_t + 0.0529 \log education_t - 0.0519 \log electricity_t + 0.0588 \log health_t + 0.1814 \log rail_t + 1.0801 \log GDP_{pc_{t-1}}$

Variables	t-stat	P-stat
constant	-1.22	0.0263
logtelecom	2.13	0.071
logeducation	4.38	0.003
logelectricity	-2.14	0.070
loghealth	1.92	0.097
lograil	0.90	0.397
logGDP <sub>pc,t-1</sub>	37.75	0.000

The table above demonstrates the results of the parameter estimates and their corresponding t-statistics and P-statistics. It can be seen that all of the explanatory variables are significant at 10% significance level except for rail. The P-value of the F statistics is zero which indicates overall significance of the model. Also the Adjusted R<sup>2</sup> value is approximately 0.99 suggesting a strong model fit.

### Estimation of Elasticity

The estimated parameters from Equation (3) are:  $\delta\beta_2=0.00468$ ,  $\delta\beta_3=0.0529$ ,  $\delta\beta_4= -0.0519$ ,  $\delta\beta_5=0.0588$  and  $(1-\delta) = 1.0801$ . Hence  $\beta_2= -0.585$  and  $\beta_3= -0.661$ ,  $\beta_4= 0.6377$ ,  $\beta_5= -0.735$  and  $\delta= -0.08010$ . The table below exhibits the short run and long telecom, education, electricity and health investment elasticity of GDP per capita in Bangladesh based on the Partial Adjustment Model.

	Short Run Elasticity	Long Run Elasticity
Telecom Investment	0.00468	-0.585
Education Investment	0.0529	-0.661
Access to Electricity	-0.0519	0.6377
Health Investment	0.0588	-0.735

The short run telecom elasticity of 0.0468 indicates that a 1% increase in investment in telecom would result in a 0.00468% increase in per capita GDP in the short run. If government expenditure on education as a share of the total government expenditure is increased by 1% then the GDP per capita will rise by 0.0529% in the short run. The GDP per capita would also increase by 0.0588% in the short run if the health expenditure as a share of GDP was raised by 1%. The same elasticities in the long run results in being negative which implies that these investments would have a negative impact on growth in the long run. According to Roland-Holst (2009) the impact of infrastructure investment on growth in a nation depends on the commitment to accelerated infrastructure investment and the initial condition of the infrastructure. Particularly, if the initial state of infrastructure is not of standard, the stimulus to growth due to infrastructure investment is relatively higher. The elasticity values obtained from this study on Bangladesh indicate that in the present scenario the condition of the telecom, education and health infrastructure is neither sufficient nor is it efficient. Hence in the short run when the investment in these infrastructures is increased, it results in a positive impact on growth. Investment in education and health infrastructures results in a relatively higher growth in GDP per capita. These infrastructures pertain to human capital and this implies that the current condition of human capital has not reached the developed stage and furthermore is not efficient. Therefore, human capital in Bangladesh requires nurture to reach its potential level. So, investment in these infrastructures would be a priority for the government if it wants to achieve a higher growth rate.

Over the long run, however, the elasticities are negative. This could mean that in the long run these infrastructures would reach a saturation level and achieve the required level of efficiency. So further expenditures in these infrastructures would have an insignificant marginal effect on GDP per capita. The cost of investing further in these infrastructures would not have a proportional incremental benefit on GDP and therefore the consequential growth rates converge to the negative side. This actually is a good sign of progress for Bangladesh because it points to the fact that Bangladesh would be able to achieve the required level of telecom, education and health infrastructure in the long run with its current projection of infrastructure investment growth. So the findings of this study would recommend the government of Bangladesh to further increase investment and government expenditure on telecom, education and health infrastructure. The current expenditure on education as a share of total government expenditure is around 16% in Bangladesh. Bangladesh can follow the examples of countries like Malaysia, Thailand and other upper middle-income countries where this share is above 20% (World Bank). The health expenditure in Bangladesh as a share of GDP is a mere 3%. Countries like Maldives that has achieved commendable growth rate and reached the upper middle-income status has health expenditure of above 11% as a share of GDP. Bangladesh can look into examples like this if it wants to progress towards the upper middle-income status (World Bank).

The elasticity of GDP per capita with respect to access to electricity has somewhat intriguing results. The short run elasticity has a negative value. This clearly suggests the severe lack of efficiency in implementing the infrastructure projects taken on by the Bangladesh government to generate electricity. The mega projects for

power generation has a substantial fund allocated towards it but the projected cost is consistently rising. In addition to this, the expected time of completion is not being met with. The elasticity values estimated in this study reinforce the fact that investment in electricity generation infrastructure in Bangladesh suffers from inefficiency, bureaucracy and corruption which has resulted in rising cost and ineffectiveness in implementing the infrastructure projects. So, this study recommends the Bangladesh government to control the rising cost of implementing electricity generation infrastructure projects. However, the long run elasticity of access to electricity has promising results. It indicates that a 1% increase in access to electricity will result in a growth of GDP per capita of 0.64%. This means that in the long run the increased access to electricity provided by the government will substantially increase the income growth of this country. Henceforth investment in infrastructure that would provide the population of Bangladesh with access to electricity has the potential to increase GDP considerably in the long run.

## V. Conclusion

Like many other LDCs, the most important challenge facing logistics development in Bangladesh appears to be infrastructure related<sup>1</sup>. Bangladesh has made significant progress in reducing poverty and reaching the lower middle-income status in 2014. 20.5 million people rose out of poverty during the period 1991-2010, moreover, life expectancy, literacy rates and per capita food production have increased by a great extent (World Bank). Growth has been maintained over 6 percent reaching a highest of 7.1 in 2015/2016. As reported in WDR (2014), by the year 2010, 83% of the rural population have access to improved water supplies; 55% have access to improved sanitation; 47% with access to grid electricity; 92% of the children are now enrolled in primary schooling; 45% have cellphones; and 65% have access to domestic credit provided by the formal financial sector. However, such rapid progress in the living standard of the people of Bangladesh increased the need for better transport, energy and urbanization. In order to sustain this growth level, Bangladesh needs to overcome the hurdles that stands in its way, namely its poor infrastructure in various sectors. Bangladesh needs to implement structural reforms, make investments in human capital, increase female participation in jobs and other sectors, and raise productivity. Reducing infrastructure gaps and improving the business climate would allow new productive sectors to develop and generate new jobs for the growing economy where about 2.1 million graduates enter the job market every year (World Bank report). Zahid Hussain who is one of the leading economist of World Bank stated, "Growth isn't on autopilot. Investment must go up for achieving this. The target cannot be reached if the present state continues. Investment must go up in both public and private sectors."

The findings in the paper suggest that investment expenditures on infrastructures like education, health and telecom need to go up if Bangladesh wants to maintain its present growth rate, if not go higher. In the short run, elasticity values suggest that more investment needs to be made, for example, spending more on education, health and telecom would bring about a higher growth in the country. The government should also be aware of not to invest when the investments reach a saturation point after which any expenditure on infrastructure might be futile. Although spending on electricity has negative impact in the short run, in the long run, by lowering the costs of implementing such infrastructure the government can reap economic benefits. The electricity companies can grow and enjoy economies of scale over the long run which would bring down the average cost of producing electricity. Although the government is taking initiatives to improve infrastructure investments by promoting various education, health, telecom and electricity facilities in Bangladesh as discussed above, it still has a long way to go. As the problem of running budget deficits for consecutive years and tax evasion by the rich still remains, it would be hard for the government to raise money for undertaking such projects in the future. Therefore, minimizing corruption, tax evasion could ensure that the government has enough money to invest more heavily in infrastructure projects.

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