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Effect of Public Investment on Economic Growth in Bangladesh: An Econometric Analysis

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Abstract
This paper explores the role of public investment in the process of economic growth, in the context of Bangladesh economy. Due to lack of recent official statistics, necessary datasets were derived by the author for the period 1973-2011. For the estimation purposes several econometric method are used. The results show that Public Investment has positive effects on GDP in Bangladesh. So increases in public investment should have a positive net impact on economic growth which augments our economic development in future. Findings point out that keeping the high public investment level in Bangladesh together with improvement in institutional surroundings would be beneficial for economic growth. This paper concludes with a number of policy recommendations arising from the research findings.
Kewords: Public Investment, Economic Growth, Unit Root Test, Co-integration test, Jarque-Bera test, Multicollinearity test, Heteroskedasticity, Likelihood Ratio Test.

Introduction

Public investment is the most important and fundamental potential factor of economic growth. It can play a vital role to ameliorate the economic situation and level of economic development of Bangladesh like other countries. Public investment influences economic growth in different ways. Recently, the spontaneous impact of public investment is lively discussed topic because of its positive impact on economic growth and other indicators of economic development. Public investment can influence positively the different sectors of an economy which aggregately augment the economic growth. Theoretically, we can say public investment multiplier increases national income of a nation in different levels with different ways. Public investment can reduce the evil effect of different negative factors of an economy like poverty, inequality, discrimination and so on. On the other hand, public investment has a positive impact on different positive sector of an economy such as income, private investment, infrastructure, science, technology, savings and others. To solve the problems of basic human needs (food, shelter, cloth, health and education) of a country, public investment can play a long term vital role. Public investment is fully organized by government, that's why it always on the favour of mass population. Public investment always highlights the welfare of public which is fully absence in private investment.

In Bangladesh perspective, the importance of public investment is impossible to deny. Due to different reasons like low infrastructure, the return of public investment is not satisfactory and still not clear. If we observe the developed countries, we can say the return of public investment is much higher compare to the third world. In Bangladesh it is possible to consider the development budget as a public investment. Generally public investment is invested in those sectors where private investment is not effective.

The idea that public investment should have a positive effect on economic growth is intuitively appealing. A number of prominent authors have argued that the link between public investment and economic growth is weak or nonexistent and the question as to whether public investment should be given preference in government budget is a controversial decision. On the other hand, a lot of researchers conclude that there is a strong tie between public investment and economic growth. The objectives of the study are**:**

- To determine the relationship between public investment and growth in the context of Bangladesh.
- Analyze the impact of public investment on GDP.
- To find the co-integrated relationship between public investment and GDP.
- To suggest policy measures for the improvement of economic situation based on the empirical results.

Literature review

Effect of public investment on economic growth is recently a sound topic for developing countries as well as others. Separately public investment and growth are lively discussed economic topics. Growth mainly depends on public investment. William E. Cullison (1993) used a simplified version of Granger- Granger – Causility test to determine that relation. He used a simulating var model to test statistically significant impacts. Then, he draws an attention that uses past data to simulate future events. He Concluded that the government spending on education and labour training and perhaps also civilian safety have statistically and numerically significant effects on future economic growth.

Robert Kuttner (1992) argues, the economy is adhering in a round resulting from the excesses of the 1980s with slow growth, stagnant wages, inadequate productive investment and institutional trauma. In such an economy, reducing government outlay as a policy of increasing investment and growth will backfire. The more likely way to restore growth is to increase investment directly, through expanded public spending on infrastructure, technology, procurement and related capital outlays.

An IMF working paper prepared by Benedict Clements, Rina Bhattacharya and Toan Que Nguyen (2003) examined the channels through which external debt affects growth in perspective of low income countries. Special attention is given to the indirect effects of external debt on growth via its impact on public investment. Re-estimating the growth equations with gross investment disaggregated into private and public investment advice that it is the latter which has an impact on growth. Using estimation methodologies they explain that the results imply that for each 1 percent of GDP increase in public investment, annual per capita growth rises by 0.2 percent. More especially they estimate a public investment equation using fixed effects. The openness indicator is included as an explanatory variable because more open economies often compete for foreign direct investment by among other things, trying to invest more in infrastructure. Thus, there is likely to be a positive relationship between openness and public investment ratio.

M. Emranul Haque and Richard Kneller (2008) examine the growth effects of public investment in the presence of corruption in developing countries. They also focus on the effect of corruption on public investment. Using aggregate output function broadly with some assumption then, they use a panel setup in four equations in the systems for baseline which is three stages least squares regression system. After econometric analysis they draw an attention that corruption increases public investment but reduces its effects on economic growth. Then they suggest that the policies to deter corruption and to increase the efficiency of public investment could give very positive impulses to economic growth.

Ejoz Ghani and Muslehud Din (2006) try to find the impact of public investment on economic growth. They are using the vecto r autoregressive (VAR) approach with the help of data (1973-2004) Pakistan. They include four variables i.e. public investment (IG), private investment (IP), public consumption (CG) and CDP (Y) in VAR approach. After analyzing, it shows that both private investment and public consumption positively influence output.

Pooloo Zainah (2009) recently discusses the role of public investment in promoting economic growth in an African island country Mauritius over the period 1970-2006. Dynamic econometric technique is used, namely a vector Error correction model (VECM) to analyze the effects. In summery their finding is that public capital has significant contribution on economic performance more specifically on economic growth.

Using a production function approach, Ebert (1986), Costa, et al.(1987) and Deno (1988) find public investment to be a significant input in the production process and private and public investments to be complementary, rather than substitutes. Navy (2002) examines the relationship between economic growth, public investment and private investment using VAR methodology. Based on annual time series data for Pakistan, the analysis suggests that public investment has a positive impact on private investment, and that economic growth drives both private and public investment as predicted by the accelerator-based models.

Alfredo M. Pereira and Maria de Fatima Pinho (2006) address the positive effect of public investment on economic performance in Portugal. This analysis follows a vector auto-regressive (VAR) approach with consideration of variables are output (Y), employment (I) private investment (IP) and public sector investment in durable goods (ig) and using data for the period 1976-2003. In order to determine the effects of public investment they use the impulse functions associated to the estimated VAR models. Estimation result suggests that public investment has a positive effect on employment, private investment and output with having a positive effect on long term economic performance.

Subarna Pal (2008) addresses on ‘does public investment boost economic growth?’ To answer this question she examines the effect of public investment not only on growth, but also on real exchange rate and net foreign assets over the last three decades in india. Generalized methods of moments (GMM), also called parametric technique used for estimation and for empirical analysis. The results show that the consideration of the growth equation estimates clearly the effect of both public investment and its square terms are significant. In addition, public investment also exerts significant influence on real exchange rate. The coefficients of the public investment is positive and the coefficient of the squared term of public investment is negative and the coefficient of real exchange rate (RER) is positive when the long run growth rate (GDPUR) is the dependent variable in GMM estimation.

Syed Adnan Haider Ali shah Bukhari, Liaqat Ali and Mahpara saddaqat (2007) have been studied to investigate whether there exists a long-term dynamic relationship between public investment and economic growth with heterogeneous dynamic panel data from Singapore, Taiwan and Korea. They looked into this relation empirically during the period 1971 -2000, by using Granger causality test on panel data and on individual country data as well. Using a variety of econometric techniques, the analysis suggests that public investment, private investment and public consumption have a long-term dynamic impact on economic growth in all countries of the sample and in the panel of sample countries. This analysis shows bi-directional causality between public investment and economic growth and homogenous non-causality hypothesis suggests that non-causality results are completely homogenous in a small sample of these mentioned countries.

Pedro Brinca (2006) analyzes the impact of public investment in Sweden with the help of VAR approach mainly, solo model production function and granger causality analysis. He covers the period from 1962 to 2003, for a total of 42 observations. This econometric result suggests the existence of an indirect of the growth rate of public investment in GDP through the growth rate of private investment as well as a feedback mechanism between the growth rate of GDP and private investment. The results of the VAR estimation show that private investment's growth rate is positively affected by innovations in public investments, growth rate, suggesting that the traditional setting of an augmented Solow production function cannot properly capture the interrelationship between variables. Looking at the impulse response functions, innovations in the growth rate of public investment has an effect in both employment and GDP growth rates.

In past two decades a large body of literature on methods for the analysis of panel regression models has emerged. An extensive treatment of methods for panel data analysis in general can be found in Baltagi (2000) and Hsiao (2003). Most important advantage of panel data sets over cross-sectional or time-series data is in larger number of data points that leads to increased efficiency of econometric estimates. The effects of public investments on output growth are still empirically ambiguous. Extensive reviews of the literature and different methodological approaches are presented by Kamps (2004) and Sturm (1998).

RESEARCH METHODOLOGY

The data set is based on secondary data and drawn from different sources comprise time series data of Bangladesh period from the fiscal year 1972/73 to 2010/2011. The general purpose of multiple regression method is to know more about the proper relationship between some explanatory variable and exogenous variable and a dependent variable or endogenous variable. Here used others econometric method such as time series analysis. The econometric tools such as unit root test, co-integration test, Granger Causality etc will be used where possible. All data are time series data. All variables are measured in millions of us dollar in constant price.

Data are the main base for any kind of research. In the third world, data of economic indicators are not fully reliable, available and transparent. Bangladesh is also not different from like other developing countries. Some data are clearly vague such as same data but from different sources are inconsistent. That's why, careful attention was implied during self complied period. Here, data are to be used in this thesis will be standard and reliable because of all sources of data are well known, recognized, widely used and accepted by government and others. So, data which used in this study must be reliable.

Proposed Model

The preliminary object of these empirical investigations is to find out the relation among three variables namely annual development program, gross capital formation and gross domestic product. Here annual development program and gross capital formation are the determinant of gross domestic product. To do this we specify a four variable model and the implied theoretical model is as follows-

$$GDP_t = f(ADP_t, GCF_t)$$

Considering the above function in context of multiple regressions, the evaluation of the above function can be done on the basis of following equation-

$$GDP_t = \beta_0 + \beta_1 ADP_t + \beta_2 GCF_t$$

To complete the specification of the econometric model, we consider the form of algebraic or linear relationship among the economic variables. In this model, GDP was depicted as a linear function of public investment. The corresponding econometric model is

$$GDP_t = \beta_0 + \beta_1 ADP_t + \beta_2 GCF_t + u_t$$

The random error e counts for the many factors which affect GDP that we have omitted from this simple model and it also include the intrinsic and random behavior in economic activity.

Variable Definitions and Data Sources

1. GDP: Gross Domestic Product (GDP) at purchaser's prices is the sum of gross value added by all resident producers in the economy plus any product taxes and minus any subsidies not included in the value of the products. It is calculated without making deductions for depreciation of fabricated assets or for depletion and degradation of natural resources. Data are in constant 2000 U.S. dollars. Dollar figures for GDP are converted from domestic currencies using 2000 official exchange rates. For a few countries where the official exchange rate does not reflect the rate effectively applied to actual foreign exchange transactions, an alternative conversion factor is used.

Source: World Bank national accounts data, and OECD National Accounts data files.

2. ADP: Actually, Annual Development Program (ADP) is considered as public investment. ADP is an organized list of projects in various sectors. ADP is prepared on the basis of a year's development budget and approved by the parliament. To covert it Crore taka to us dollar we use the average exchange rate with base year 2000/2001.

Source: Implementation Monitoring and Evaluation division, ministry of planning, government of Bangladesh and self compiled

3. GCF: Gross Capital Formation (GCF) which is formerly gross domestic investment and it consists of outlays on additions to the fixed assets of the economy plus net changes in the level of inventories. Fixed assets include land improvements (fences, ditches, drains, and so on); plant, machinery, and equipment purchases; and the construction of roads, railways, and the like, including schools, offices, hospitals, private residential dwellings, and commercial and industrial buildings. Inventories are stocks of goods held by firms to meet temporary or unexpected fluctuations in production or sales, and "work in progress." According to the 1993 SNA, net acquisitions of valuables are also considered capital formation. Data are in constant 2000 U.S. dollars.

Source: World Bank national accounts data, and OECD National Accounts data files.

Expected Signs of the Estimated Coefficients

1. $\beta_0 \rangle 0$; Autonomous GDP when ADP and GCF are zero though it is not very important.
2. $\beta_1 \rangle 0$; if ADP increase then the GDP must be increased.
3. $\beta_2 \rangle 0$; if GCF increase then the GDP is also increased.

EMPIRICAL ANALYSIS

Finally we consider the following model because of economic significance.

$$GDP_t = \beta_0 + \beta_1 ADP_t + \beta_2 GCF_t + u_t$$

This study proceed with the OLS method.

Descriptive Statistics of All Variables

With the help of E-views, the descriptive statistics of ADP, GCF, GDP are as follows:

Table-1

	ADP	GCF	GDP
Mean	2023551417.11	8029994335.12	38726349794.91
Median	1421188630.49	5115856784.60	32010406325.13
Maximum	7131782945.73	24353431450.07	88507817580.73
Minimum	99582588	498060373.68	1586254341.02
Std. Dev.	1786098874.03	6733854274.00	20478926960.04
Skewness	0.891632	0.922952	0.905424
Kurtosis	3.039959	2.661811	2.732600
Jarque-Bera	5.170143	5.722821	5.444839
Probability	0.075391	0.057188	0.065716
Sum	78918505267.34	313169779069.79	1510327642001.72
Sum Sq. Dev.	1.21E+20	1.72E+21	1.59E+22
Observations	39	39	39

- All data are in US dollars

From the table we consider that the frequency distributions of all variables are not normal. Skewness is a measure of a distribution about its mean. The skewness values of all variables are less than unit and nearest to zero. The kurtosis values of all variables are closed to 3 which indicate that the distributions of all variables are normal. Kurtosis measures the peakedness or flatness of a distribution. Kurtosis value of ADP indicates that it is leptokurtic distribution and the other two variables (GDP and GCF) are platy kurtic distribution.

Analysis of Results

Estimated results with Ordinary Least Square method has been reported in Table-2. (According to Appendix -1)

Table -2: Regression Results

	Coefficient	Std. Error	t-Statistic	Prob.
C	14439454875.46	275460712.81	52.41929	0.0000
ADP	1.292874	0.575230	2.247576	0.0308
GCF	2.698719	0.152575	17.68781	0.0000

Table 3, shows the summary of the above model.

Table-3: Model Summary

R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
.891	0.997349	0.997201	1.08E+09	0.561985

From, E-views results we can say that the coefficients of all explanatory variables are positive which make economic sense. The constant coefficient is also making an economic sense although it is not necessary to consider statistically meaningful. The general meaning of constant coefficient indicates that if ADP and GCF are zero then we will enjoy 14439454875.46 units GDP. It is equivalent to autonomous GDP. Coefficient of ADP and GCF indicate that the 1 unit increase of ADP and GCF ensure the GDP also increase 1.292874 and 2.698719 unit respectively. It makes economic sense but we need to consider it statistically.

Variance Analysis test

From Appendices -1,According to ANOVA (Analysis Of Variance) table, the value of F statistic is 96.90957 and probability value is 0.00. It is indicate that R^2 is statistically significant.

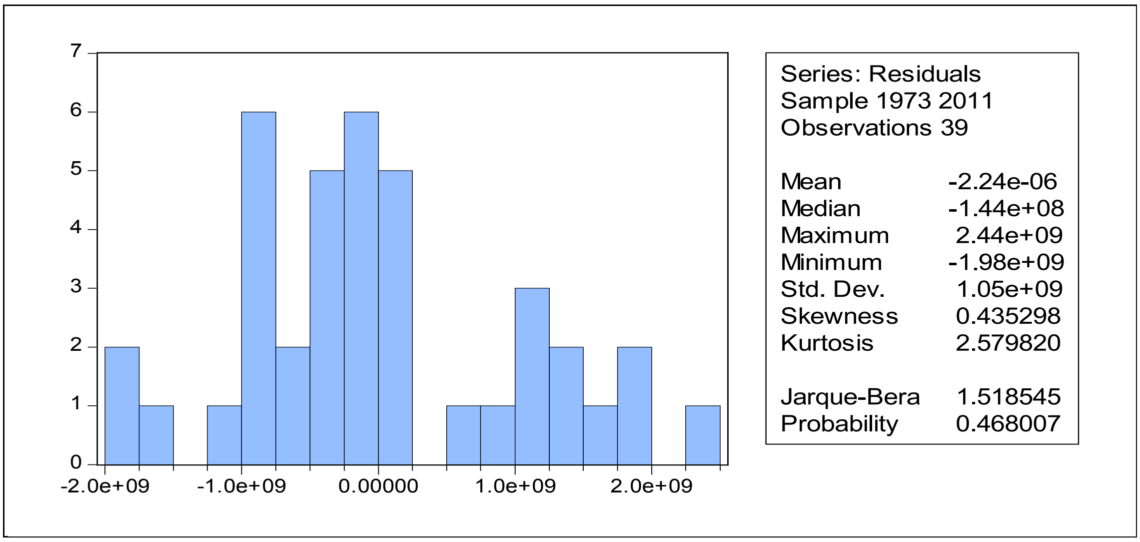
Jarque –Bera test

We can compute Jarque-Bera test statistic using the following rule:

$$JB=n[S^2/6+(K-3)^2/24]$$

Where, n= sample size, s= skewness coefficient and k= kurtosis coefficient. If s=0 and k=3 then the value of the J-B statistic is expected to be 0. In our model, the JB value is 1.51. The 5% critical value from a chi-square distribution with 3 degrees of freedom is 7.815 and 1% critical value is 11.345. because of 1.51< 7.815 and 1.51<11.345 so there is insufficient evidence from residuals to conclude that the normal distribution assumption is unreasonable at the 5% and 1% level of significance

Figure -1



Tests for Multicollinearity

Multicollinearity is a sample phenomenon; we don't have a unique method of testing multicollinearity. For detecting multicollinearity in our model, we use E-VIEWS.

Correlation matrix

Correlation matrix is one of the best techniques to detect multicollinearity. Now let's have a look at the following correlation matrix.

Table-4: Correlation matrix

	ADP	GCF	GDP
ADP	1.000000	0.985260	0.987069
GCF	0.985260	1.000000	0.998487
GDP	0.987069	0.998487	1.000000

According to the Table-4, it can be seen that some variables are highly correlated with one another. So, we can conclude from our correlation matrix the variables are highly correlated and all values are greater than conventional level. That is multicollinearity problem exists in this model.

So we can see, several of these pair-wise correlations are quite high, suggesting that there may be a several collinearity problem. Of course, remember the warning given earlier that such pair-wise correlations may be sufficient but not a necessary condition for the existence of multicollinearity.

Tests for Heteroskedasticity

Homoskedasticity is an important property for OLS method. So it is important to find out whether there is any heteroskedasticity problem or not. To test heteroskedasticity, we have used the **"**Breusch–Pagan-Godfrey Test**".**

Breusch–Pagan-Godfrey Test:

Here the null and alternative hypotheses are;

Ho: There is no heteroskedasticity

Ha: There is heteroskedasticity problem

The formula of the Breusch-Pagan-Godfrey test shows as follows:

$$\chi^2 = N*R^2 \sim_{asy} \chi^2_{(s-1)}$$

Where χ^2 shows chi-square distribution with (s-1) degrees of freedom

Our observed χ^2 = 13.31590. . If the computed χ^2 exceeds the critical chi- square value at the chosen level of significance, we can reject the hypothesis of homoscedasticity; otherwise does not reject it. In our model, chi-square value is 13.31590 with 2 df the 5% and 1% critical chi square value are 5.99147 and 9.21034 which are less than computed chi-square. Therefore, we reject the hypothesis of homoscedasticity. So, our model is not free from heteroscedasticity. .(According to appendix-5)

Remedy of Heteroscedasticity

we use white Heteroscedasticity -Consistent Standard Errors and Covariance(Appendices -2). Now, we compare our estimation output from the uncorrected OLS regression with the heteroscedasticity consistent covariance output. Note that in our model the coefficients are the same but uncorrected standard error is smaller. It means that the heteroscedasticity consistent covariance method has reduced the size of the t-statistics for the coefficients. It helps us to avoid incorrect values for test statistics in the presence of heteroscedasticity.

Test for Autocorrelation

In order to conduct Durbin-Watson test statistic, following assumptions must be satisfied:

1) It is necessary to include a constant term in the regression.
2) The explanatory variables are non-stochastic, in repeated sampling.
3) The disturbance terms U_t are generated by the first order auto-regressive scheme.
4) The regression model does not include lagged values of the dependent variable as one of the explanatory variables.
5) There are no missing observations in data.
6) The error term U_t is assumed to be normally distributed.

In the absence of software that computes a p-value, a test known as the bounds test can be used partially overcome the problem of not having general critical values Durbin & Watson considered two other statics d_l & d_u whose probability distribution do not depend on the explanatory variables and which have the property that

$$\mathbf{d_l < d < d_u}$$

That is, irrespective of the explanatory variables in the model under consideration will be bounded by an upper bound d_u and 0 a lower bound d_l. If $\mathbf{d < d_l}$ H_0 is rejected and $\mathbf{d > d_u}$ is not rejected. Our regression model is qualified by all these assumptions. So, we can use Durbin-Watson test. The test procedure is as follows:

$H_0 : p = 0$ (No Autocorrelation)

And, $H_1 : p > 0$ (Positive Autocorrelation)

In our model, calculated value of d=0.561985, against for n=39, k=2 and α=5%, The lower bound d_l

=1.382 and an upper bound d_u =1.597 at 5% level of significance. So we can reject H_0 because of d< d_l. At 1% level of significance also gives same decision. We conclude that there is statistically significant evidence of positive first order serial correlation. (Acoording to Appendix-1) For reducing this problem, we can apply "Cochrane-Orcutt" iterative procedure to estimate ρ, where, ρ is known as the coefficient of auto-covariance. After that we can have a conclusion with the help of EGLS technique.

Specification Test

Likelihood Ratio Test

In our model, we get the F-statistic with its p-value and a likelihood ratio test with p-value. Both p-values are 0.00, so we reject the hypothesis that the coefficient of this variable is zero **(appendix-4).**

RESET Test

Examining the model misspecification is a formal way to know whether our model is adequate or whether we can ameliorate on it. It could be miss-specified if we have omitted important variable, included irrelevant ones, chosen a wrong functional form or have a model that violates the assumption of the multiple regression model. J B Ramsey (1969) has proposed a general test of specification error called reset (Regression Specification Error Test) which is designed to detect omitted variables and incorrect functional form. This test is proceed as follows- We have specified and estimated the equation-

$$GDP_t = \beta_0 + \beta_1 ADP_t + \beta_2 GCF_t + u_t$$

Let, (b_1, b_2, b_3) be the LS estimates and let,

$$GDP_t = b_0 + b_1 ADP_t + b_2 GCF_t$$

$\widehat{GDP}t$ Is obtain and then consider the following artificial model-

$$GDP_t = \beta_0 + \beta_1 ADP_t + \beta_2 GCF_t + G\hat{D}P^2 + u_t$$

Now, if δ_1 is statistically insignificant then it can be conclude that there is no misspecification with omitted variables and wrong functional form. Rejection of null hypothesis implies that the original model is inadequate and can be improved when $F_{cal} > F_{cri}$.

From our model, **(appendix-5)** the calculated value of F is 0.1630 and at the 5% and 1% level of significance with J=1 and df=n-k=39-4=35 the critical values are 4.12 and 7.42 respectively. Here, $F_{cal} < F_{cri}$. So, we cannot reject the null of no misspecification. According to p-value we can conclude same conclusion. On the other meanings, δ_1 is not statistically significant since its p value is 0.68. Therefore, we can draw a conclusion that our model does not contain any major problem of incorrect functional form and omitted variable.

Unit Root Test

Augmented Dickey Fuller Test(ADF):

In the Dickey-Fuller test it is assumed that the error term is uncorrelated. But in case the error terms are correlated, Dickey and Fuller(1979) have developed a test, known as the Augmented Dickey-Fuller test. In ADF we still test null hypothesis what is "there is an unit root" and the ADF test follows the same asymptotic distribution as the DF statistic, so the same critical values can be used. So, we can reject the null hypothesis when |t-value|>|τcri|, otherwise H_0 can be accepted. In general, by testing null hypothesis against alternative, the unit root test can be rejected if the t test statistic is negatively less than the critical value tabulated. The significance levels for all critical values are 1%, 5% and 10%. We cannot reject null of a unit root since; the p value is too high. To determine the order of integration and to test stationary as well as unit root test will be carried out using the ADF test for all respective variables.

Table-5: Augmented Dickey-Fuller Test for FDI, GCF and GDP at Level

Variable	None		Intercept		Intercept+Trend		Decision
ADP	3.497986	-2.630762*	2.777848	-3.626784*	0.820038	-4.234972*	Nonstationary
		-1.950394**		-2.945842**		-3.540328**	
		-1.611202***		-2.611531***		-3.202445***	
GCF	4.417581	-2.632688*	4.477215	-3.632900*	2.894064	-4.243644*	Nonstationary
		-1.950687**		-2.948404**		-3.544284**	
		-1.611059***		-2.612874***		-3.204699***	
GDP	4.228387	-2.628961*	20.07758	-3.615588*	7.507894	-4.219126*	Nonstationary
		-1.950117**		-2.941145**		-3.533083**	
		-1.611339***		-2.609066***		-3.198312***	

Note: *, ** and *** indicate the 1%, 5% and 10% critical value respectively

Table-6: Augmented Dickey-Fuller Test for FDI, GCF and GDP at First Difference

Variable	None		Intercept		Intercept+Trend		Decision
ADP	-0.628838	-2.628961*	-1.367559	-3.621023*	-2.912977	-4.234972*	Nonstationary
		-1.950117**		-2.943427**		-3.540328**	
		-1.611339***		-2.610263***		-3.202445***	
GCF	1.941585	-2.636901*	0.515212	-3.646342**	-2.735238	-4.243644*	Nonstationary
		-1.951332**		-2.954021**		-3.544284**	
		-1.610747***		-2.615817***		-3.204699***	
GDP	3.502567	-2.632688*	4.063533	-3.670170*	2.131143	-4.296729*	onstationayNr
		-1.950687**		-2.963972**		-3.568379**	
		-1.611059***		-2.621007***		-3.218382***	

Note: *, ** and *** indicate the 1%, 5% and 10% critical value respectively

Table-7: Augmented Dickey-Fuller Test for FDI, GCF and GDP at Second Difference

Variable	None		Intercept		Intercept+Trend		Decision
ADP	-6.071317	-2.630762*	-6.122153	-3.626784*	-6.285922	-4.234972*	Stationary
		-1.950394**		-2.945842**		-3.540328**	
		-1.611202***		-2.611531***		-3.202445***	
GCF	-4.424948	-2.634731*	-4.730483	-3.646342*	-4.920096	-4.262735*	Stationary
		-1.951000**		-2.954021**		-3.552973**	
		-1.610907***		-2.615817***		-3.209642***	
GDP	-11.84907	-2.630762*	-13.60938	-3.626784*	-5.998070	-4.243644*	Stationary
		-1.950394**		-2.945842**		-3.544284**	
		-1.611202***		-2.611531***		-3.204699***	

Note: *, ** and *** indicate the 1%, 5% and 10% critical value respectively

Trade-off between Loss of Efficiency and Loss of Information

Due to mixed result of different unit root tests the decision about model and the question of stationarity of data comes next. The answer to this question involves an assessment of the trade-off between the loss of efficiency and loss of information. A model specified with levels, when time serieses are nonstationary, will generate estimate that may be spurious. On the other hand a model specified with difference, when serieses are nonstationary will generate estimates that are efficient but will ignore potential long run relationships. Sims(1980a) and Doan(2000), recommend against differencing even if the variable contains a unit root because it throws away information concerning the co-movement of variables. Fuller (1976) shows that differencing produces no gain in asymptotic efficiency even if it is appropriate. Although we conduct unit root tests and got mixed result but following Sims and Doan, the present study uses levels rather than difference of the variables involved.

Consequences of Non Stationarity

1. Spurious regression results. 2. Exceptionally high r-square and t ratios, 3. No economic meanings

Spurious Regression

The main reason why it is important to know whether a time series is stationary or nonstationary before one embarks on a regression analysis is that there is a danger of obtaining apparently significant regression results from unrelated data when nonstationary series are used in regression analysis. Such regressions are said to be spurious (lim et al). In shortly, we can say a spurious or nonsensical relationship may be occurred when one non-stationary variable is regressed against one or more non-stationary time series.

Rule of Thumb

According to Granger and Newbold, an $R^2 > d$ is a good rule of thumb to suspect that the estimated regression is spurious. d stands for Durbin-Watson stat. From our result, R^2 = 0.997349 which is greater than Durbin-Watson stat =0.561985. Regression result is seems to be spurious according to rule of thumb. So, we need formal diagnostic test to check whether our regression is spurious or not. Co-integration test is widely use formal test for testing the reliability of regression result.

Co-Integration Test

Unit Root Test on Residuals/ Engle Granger Test/ Augmented Engle Granger Test

If the residual series of the regression has a unit root then this regression result will spurious where used variables are not integrated of order zero, I(0). We can use different test for unit root on the residuals estimated from the cointegrating regression. Here, we consider ADF test only.

We can set the null and alternate hypotheses are-

H_0 : The series are not cointegrated=residuals are non stationary

H_1 : The series are cointegrated=residuals are stationary

Augmented Dickey-Fuller test for residual series of regression at level

Variable	None		Intercept		Intercept+Trend		Decision
Residual	-1.692409	-2.632688*	-1.666872	-3.632900*	-3.739045	-4.226815*	Stationary at 10%
		-1.950687**		-2.948404**		-3.536601**	
		-1.611059***		-2.612874***		-3.200320***	

Note: *, ** and *** indicate the 1%, 5% and 10% critical value respectively

In our model, we use nonstationary variables and the estimated residual shows the non stationary property at 1% and 5% critical value. But at 10% critical value it is stationary. So, we can draw a conclusion that GDP,ADP and GCF are not co-integrated at 1% and 5% critical value and regression result is spurious. There is no long run equilibrium relationship among GDP,ADP and GCF. But if we consider the 10% level critical value all variables are co-integrated and there is a long run equilibrium relationship among them which indicates that our regression is not spurious.

Summary of Results

We have examined the different types of statistical properties for our model. From our regression model, we have seen that the probability value of ADP and GCF are satisfactory at the level of significance 5%. That means ADP and GCF are significantly impact GDP. ANOVA model refers that goodness of fit is statistically significant. Graphical method makes the decision that the model is normally distributed.Graphical test indicates our model is not free from heteroscedasticity. That's why we consider the remedy. In the time series data autocorrelation is widely used term. Durbin Watson test ensures the statistically significant evidence of positive first order serial correlation. We use Likelihood Ratio test to assess the specification of our model. In both cases the results indicate that the model is well specified. The RESET test concludes that our model does not contain any major problem of incorrect functional form and omitted variable. To ensure the efficiency of any regression analysis we have to consider the used time series data whether stationary or not. To find out the stationary properties we use ADF which indicates a mixed result. Because of mixed result of stationary, we discussed about trade-off between loss of efficiency and loss of information. Due to non-stationary results, it has a scope of spurious regression and no economic meanings. Although rule of thumb indicates the spurious regression but the formal test does not ensure it. Unit root test on residuals is used as test for Cointegration. This result implies that the all series under consideration are driven by common trends. After that, we assess the pair wise causality. By considering the whole analysis of results, we can conclude that there is a long run relationship between public investment and economic growth. Coefficient of ADP and GCF indicate that the 1 unit increase of ADP and

GCF ensure the GDP also increase by 1.292874 and 2.698719 unit respectively. At last we can say public investment has positive impact on GDP of Bangladesh. So, we can enhance our economic growth by ensuring adequate public investment.

Conclusions and policy implications

This study examines the relationship between public investment and economic growth of Bangladesh. We applied appropriate econometric test, process into the data from 1972 to 2011 to show the relationship. The results indicate that public investment (mainly we consider ADP as a proxy of public investment) has significant effects on economic growth of Bangladesh. So, the government's action and policies are necessary to unleash economic growth by way of implementing ADP properly. Here it should be mentioned that the political stability, transparency guarantee to abolish corruption, skilled workforce, and developed infrastructure are essential to maintain the standard rate of implementing ADP as well as growth of ADP. If the government can ensure these necessary steps, ADP will impact more positively in our economic growth.

The government should consider some necessary steps to prevent the problems which described before because we find the effective relation between public investment and Economic growth. Political institutions and actors should be more compromising and consolidate democracy with stable situation for the economic development of the country. The administrative structure should be more accountable and transparent to achieve a good governance system that restrains corruption. The government should enforce monitoring and evaluation procedures in establishing the infrastructures that can ensure more implementation status of ADP. We should also emphasize human resource development through practical education and training programs. We believe that if government considers it then economic growth will enhance.

Direction for Future Research

The simple model we developed in this study may suffer from a number of shortcomings. Therefore, some venues for future research may be considered. They are as follows:

This study uses annual time series data, which may mask some important dynamic aspects. An analysis based on quarterly or monthly data should certainly be more enriching. But availability of monthly data for Bangladesh would continue to be a major stumbling block at least in the foreseeable future. An important driving force of future research in time series analysis is the advance in high-volume data acquisition. . Further work could apply the methodologies developed for this study to a range of other developing countries. However, the estimation equations should be constructed to fit the specific public finance structure in each country. Further studies using different conditions for public investment, for example, different types of dummy could add significant insight on the effects of economic growth in our country. Moreover, from the review of the literature, public investment can *crowd in* private investment. These data will be available in future and must be processed properly and efficiently. But the special features of the data, such as large sample sizes, heavy tails, unequally spaced observations, and mixtures of multivariate discrete and continuous variables, can easily render existing methods inadequate. Analyses of these types of data will certainly influence the directions of future research.

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Appendices

Appendix-1

Dependent Variable: GDP
Method: Least Squares
Date: 10/04/14 Time: 21:48
Sample: 1 39
Included observations: 39

	Coefficient	Std. Error	t-Statistic	Prob.
C	1.44E+10	2.75E+08	52.41929	0.0000
ADP	1.292874	0.575230	2.247576	0.0308
GCF	2.698719	0.152575	17.68781	0.0000

R-squared	0.997349	Mean dependent var	3.87E+10
Adjusted R-squared	0.997201	S.D. dependent var	2.05E+10
S.E. of regression	1.08E+09	Akaike info criterion	44.51842
Sum squared resid	4.23E+19	Schwarz criterion	44.64639
Log likelihood	-865.1093	Hannan-Quinn criter.	44.56434
F-statistic	6770.731	Durbin-Watson stat	0.561985
Prob(F-statistic)	0.000000		

Appendix-2

Test for Equality of Means Between Series
Date: 10/04/14 Time: 00:53
Sample: 1973 2011
Included observations: 39

Method	df	Value	Probability
Anova F-test	(2, 114)	96.90957	0.0000
Welch F-test*	(2, 54.3372)	74.44398	0.0000

*Test allows for unequal cell variances

Analysis of Variance

Source of Variation	df	Sum of Sq.	Mean Sq.
Between	2	3.02E+22	1.51E+22
Within	114	1.78E+22	1.56E+20
Total	116	4.80E+22	4.14E+20

Category Statistics

Variable	Count	Mean	Std. Dev.	Std. Err. of Mean
ADP	39	2.02E+09	1.79E+09	2.86E+08
GCF	39	8.03E+09	6.73E+09	1.08E+09
GDP	39	3.87E+10	2.05E+10	3.28E+09
All	117	1.63E+10	2.03E+10	1.88E+09

Appendix-3

Heteroskedasticity Test: Breusch-Pagan-Godfrey

F-statistic	9.332083	Prob. F(2,36)	0.0005
Obs*R-squared	13.31590	Prob. Chi-Square(2)	0.0013
Scaled explained SS	8.962390	Prob. Chi-Square(2)	0.0113

Test Equation:
Dependent Variable: RESID^2
Method: Least Squares

	Coefficient	Std. Error	t-Statistic	Prob.
C	1.33E+17	2.92E+17	0.455740	0.6513
ADP	-1.16E+09	6.11E+08	-1.902183	0.0652
GCF	4.11E+08	1.62E+08	2.537673	0.0156

R-squared	0.341433	Mean dependent var	1.08E+18
Adjusted R-squared	0.304846	S.D. dependent var	1.38E+18
S.E. of regression	1.15E+18	Akaike info criterion	86.08475
Sum squared resid	4.76E+37	Schwarz criterion	86.21271
Log likelihood	-1675.653	Hannan-Quinn criter.	86.13066
F-statistic	9.332083	Durbin-Watson stat	1.002637
Prob(F-statistic)	0.000543		

Appendix-4

Redundant Variables: GDP(-1)

F-statistic	267.2661	Prob. F(1,34)	0.0000
Log likelihood ratio	82.90207	Prob. Chi-Square(1)	0.0000

Test Equation:
Dependent Variable: GDP
Method: Least Squares
Sample: 2 39
Included observations: 38

	Coefficient	Std. Error	t-Statistic	Prob.
C	1.44E+10	2.88E+08	50.15539	0.0000
ADP	1.293566	0.583542	2.216748	0.0332
GCF	2.698296	0.154976	17.41107	0.0000

R-squared	0.997256	Mean dependent var	3.93E+10
Adjusted R-squared	0.997100	S.D. dependent var	2.04E+10
S.E. of regression	1.10E+09	Akaike info criterion	44.54838
Sum squared resid	4.23E+19	Schwarz criterion	44.67766
Log likelihood	-843.4192	Hannan-Quinn criter.	44.59438
F-statistic	6360.850	Durbin-Watson stat	0.556897
Prob(F-statistic)	0.000000		

Appendix-5

Ramsey RESET Test:

F-statistic	0.163081	Prob. F(1,35)	0.6888
Log likelihood ratio	0.181296	Prob. Chi-Square(1)	0.6703

Test Equation:
Dependent Variable: GDP
Method: Least Squares
Included observations: 39

	Coefficient	Std. Error	t-Statistic	Prob.
C	1.44E+10	3.48E+08	41.24621	0.0000
ADP	1.276830	0.583390	2.188639	0.0354
GCF	2.758826	0.214445	12.86494	0.0000
FITTED^2	-1.92E-13	4.75E-13	-0.403833	0.6888

R-squared	0.997361	Mean dependent var	3.87E+10
Adjusted R-squared	0.997135	S.D. dependent var	2.05E+10
S.E. of regression	1.10E+09	Akaike info criterion	44.56506
Sum squared resid	4.21E+19	Schwarz criterion	44.73568
Log likelihood	-865.0186	Hannan-Quinn criter.	44.62628
F-statistic	4408.939	Durbin-Watson stat	0.548392
Prob(F-statistic)	0.000000		