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Abstract

The aim of this paper is to examine the relationship between public and private investment in Bangladesh over the period 1981-2015. We also investigate how the relationship between these two variables is affected by liberalization of the financial and trade sectors - an issue received less attention in previous studies. To this end, we estimate a model with three different specifications in the autoregressive distributed lag bound testing framework using real private investment, real public investment, real GDP, the real interest rate, and a dummy variable for liberalization. Our results show that public investment negatively affects private investment both in the long run and short run, suggesting that public investment crowds out private investment. However, the crowding-out effect is partially offset by liberalization which augments private investment. The findings of this paper have important policy implications in deciding the role of the government in investment and policies related to liberalization.

JEL classification: E22, H54
Keywords: Private investment, public investment, crowding-out, liberalization, ARDL bound test

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1. Introduction

Bangladesh is one of the fastest growing economies in the world, though its growth rate has been stagnant around 6% since the last decade. Recently, the government of Bangladesh has designed its Seventh Five Year Plan for the period 2016-2020 to surpass this 6% growth trap by accelerating the GDP growth rate progressively to 8% by 2020. To attain this higher growth rate, total investment including both public and private investments will be required to increase gradually from 28.9% to 34.4% of GDP by 2020 (Planning Commission 2015). Since domestic private investment constitutes a large chunk (around 76%) of total investment in Bangladesh, undoubtedly private investment will have to play a crucial role in attaining the targeted higher growth rate. In recent years, the government has been putting more emphasis on public investment to attain higher GDP growth. Consequently, public investment in Bangladesh has been rising at a faster pace (increased from 4.50% in 2008 to 6.90% of GDP in 2015), while private investment has been relatively stagnant since 2008, hovering around 22% of GDP. This trend seems to suggest a possibility of a crowding-out effect of public investment on private investment. Therefore, in this paper, we attempt to investigate how public investment affects private investment in Bangladesh.

Macroeconomic theory predicts ambiguous effects of public investment on private investment. Public investment can affect private investment either positively or negatively. Within the Keynesian framework, increase in public investment can be helpful to private investment if the government invests in infrastructure, capacity enhancing projects of human resources development. These types of public investments encourage private investment by raising productivity of private investments and in turn, creates a crowding-in effect. Contrary to the Keynesian view, neoclassical theory predicts crowding-out of private investment in the long run. According to this view, if public investment is financed by domestic borrowings, it reduces the availability of funds for private investment which pushes the interest rates up and reduces private investment.

Empirical evidence also shows no consensus about the crowding-out hypothesis. One set of studies that find the evidence of crowding-out effect of public investment includes Voss (2002) for the USA and Canada, Narayan (2004a) for Fiji, Mitra (2006) for India, Cavallo and Daude (2011) for 116 developing countries, and Sahu and Panda (2011) for India, while Aschauer (1989) for the USA, Ramirez (1994) for Mexico, Argimon, Paramo and Roldan (1997) for OECD countries, Hyder (2001) for Pakistan, Martinez-lopez (2006) for Spanish regions, Ang (2010) for Malaysia, and Hatano (2010) for Japan observe the existence of crowding-in effect.

For the particular case of Bangladesh, Majumder (2007), and Hassan and Salim (2011) investigate the crowding-out hypothesis. Using the Johansen cointegration approach, Majumder (2007) finds the existence of a crowding-in effect in the long run for the period 1976-2006, while Hassan and Salim (2011) observe crowding-out effect of public investment both in the long run and short run for the period 1981-2003. Therefore, the issue of crowding-out still is an unresolved question in the context of Bangladesh.

Moreover, these two studies have some shortcomings in various grounds. To test the crowding-out hypothesis, Majumder (2007) uses domestic public borrowings as an explanatory variable, although crowding-in is not necessarily directly related to domestic public borrowings; instead it is closely related to public capital expenditure. In this respect, Mitra (2006) argues that crowding-out or crowding-in is essentially the reaction of private sectors' investment decision to the government investment; it seems

more appropriate to analyze these variables directly. Besides, Majumder (2007) uses nominal interest rate as an explanatory variable in the private investment function, while Mankiw (2009: 63) suggests considering the real interest rate as a determinant of investment, as it measures the true cost of borrowing. On the other hand, Hassan and Salim's (2011) study suffers from small sample size (only 23 observations). Moreover, they have dropped the interest rate variable from their final estimation, though theoretically, interest rate is one of the channels of crowding-out. Our current paper tries to overcome the shortcomings of these two papers and provides a fresh answer to the question of how public investment affects private investment in Bangladesh both in the long run and short run.

In addition, we examine if there is any discernible effect of liberalization on the relationship between public and private investment as the trade and financial sectors of Bangladesh went through a liberalization reform in the early 1990s. This issue got less attention in previous works. A review of existing literature shows that only Cavallo and Daude (2011) examined this issue and they found that trade and financial deregulation had a dampening effect on the crowding-out effect of public investment.

The rest of the paper is structured as follows. The next section delineates some stylized facts of investment in Bangladesh. Section 3 provides a short description of the empirical model and section 4 discusses the sources of data and econometric methodology of the study. Section 5 presents the results of the study. Section 6 analyses the results and section 7 concludes the study with policy implications for Bangladesh.

2. Liberalization and Private Investment in Bangladesh: Some Stylized Facts

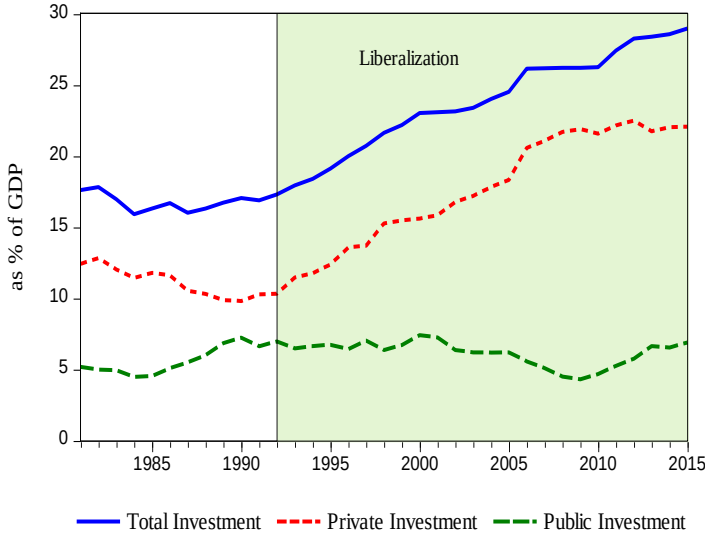
The trend of private investment is less impressive in Bangladesh, even though it shows an increasing trend. This picture was more depressing in the early period of the independence, when the economy was inward looking and the government followed a strategy of public sector led industrialization. Immediately after the independence in 1971, the government tookover all industrial unit abandoned by non-Bengali entrepreneurs and also nationalized most of the large and medium scale industrial enterprises, financial institutions and foreign trade. As a result, 92% of the industrial sector went under public ownership in early 1972 (Muhith 1999: 264). At the same time, private investment was restricted by high government control. Private enterprises were not allowed to exceed an initial fixed asset value of TK. 2.5 million (Khan and Hossain 1989: 80).

However, the performance of the economy under the inward looking and public sector led development strategy was unsatisfactory. Consequently, the government had started to relax the restrictive policies since the second half of 1974, though the deregulation of private investment got momentum after 1975. As a part of this policy change, the ceiling on private investment in the industry sector was increased by twelve times to Tk. 30 million in July 1974 (Khan and Hossain 1989: 80). The government denationalized 116 enterprises during the period of 1975-1978. In 1976, the government established the Investment Corporation of Bangladesh and reopened the stock exchange. Finally, in 1978, restrictions on private investment were completely abolished. However, the adoption of New Industrial Policy (NIP) in June 1982 was the most important move toward liberalization which made a room for an increasing role for the private sector (World Bank 1995). Subsequently, the government introduced a more liberalized version of industrial policy in 1991 which was revised further in December 1992. Relaxation of several restrictions on private investment (such as the abolition of license requirement for private investment, and opening up of telecommunications, power generation, and domestic air transport to the private sector) was the main features of the industrial policies of 1991 and 1992.

To make the trade regime more liberal and outward oriented, reform initiatives were undertaken in the mid-1980s. Initially, the steps of the reforms were *ad hoc* and focused on the removal of quantitative restriction on imports (World Bank 1999). However, trade liberalization efforts picked up its pace in early 1990s emphasizing rationalization and reduction of import tariffs and removal of quantitative restrictions. In addition, incentives were also given to boost exports and diversify the export base. At the same time, government took some other policy measures such as unification of exchange rate system by eliminating the secondary exchange market system, adoption of a moderately flexible exchange rate policy and inception of current account convertibility in 1994. Consequently, on the one hand, trade liberalization helped to boost export that led to an increase in investment demand in the export oriented sectors. On the other hand, reduction of tariff and removal of quantitative restrictions helped to ease the import of machinery, raw materials and intermediate goods that also expedited private investment.

The financial sector has also undergone major transformation through various reforms. The first round of reform started in 1982 focusing on the approval of private commercial banks as well as privatization of nationalized commercial banks[1]. However, major reforms of the financial sector took place in the early 1990s under the financial sector reform program (FSRP).Interest rate liberalization was one of the main objectives of this reform. Under the FSRP, interest rate bands for all sectors except agriculture, export, and small and cottage industries were withdrawn in April 1992 and banks were allowed to fix their own rate of interest (Bangladesh Bank 1992). In addition, credit quotas were abolished to reduce the directed lending which eased the flow of credit to the private sector and stimulated private investment in the subsequent years. Furthermore, various measures under the FSRP helped to accelerate domestic saving mobilization that also contributed to finance private investment.

Figure 1: Trends of Investment in Bangladesh: 1981-2015



Source: World Development Indicators 2016

Private investment as a ratio of GDP increased steadily to 21.89% in 2009 from 9.81% in 1990, while it exhibited a falling trend in the period before 1990 (Figure 1). On the other hand, public investment to GDP ratio remained stagnant at 6-7% during the period 1990-2000 and then came down to 4.32% in 2009. Noticeably, public investment grew at a faster pace after 2009, while private investment

[1] In the early 1980s, the government permitted to open four new private commercial banks and privatized three nationalized banks.

grew at slower rate. These trends warrant an investigation into whether public investment crowded-out private investment in Bangladesh.

3. The Model Specification

According to the flexible accelerator model, investment is defined as the rate of adjustment of the gap between the desired capital stock and the existing capital stock which can be expressed as follows:

$$I_t = \lambda(K^* - K_{t-1})$$

where I_t = investment in current period, K^* = desired capital stock, K_{t-1} = capital stock at the end of last period and λ = a fraction or a rate at which the gap between desired capital stock and existing capital stock is closed in each period.

Since the value of K_{t-1} is given in the current period, factors that affect desired capital stock also affect investment in the same ways. Desired capital stock depends positively on the level of output and negatively on rental cost of capital. Real interest rate can be used as a proxy for the rental cost of capital. Therefore, according to this model, level of output and real interest rate are two prime determinants of private investment.

However, Chirinko (1993) points out that formal models of investment have generally not been very successful in empirical implementation and hence in providing insights into the determinants of investment spending. Following the same argument, Voss (2002) comments that there is little guidance regarding the use of appropriate theoretical models of investment in which the empirical evidence can be supported. Hence, in this study, we adopt a modified version of flexible accelerator model for private investment where we introduce public investment as an explanatory variable in addition to output and real interest rate, as theoretical and empirical literatures suggest that public investment can affect private investment. This modification gives us following equation for private investment:

$$\text{Model 1:} \qquad PI_t=\alpha_0+\alpha_1 Y_t+\alpha_2 R_t+\alpha_3 GI_t+ \varepsilon_t \tag{1}$$

where PI = real private investment, Y = real output measured by real GDP, R = real interest rate, GI = real public investment and ε_t = error term. α_1, α_2 and α_3 are the elasticity of private investment to change in real output, real interest rate and real public investment respectively. *A priori*, the sign of α_1 and α_2 are expected to be positive and negative respectively, while the sign of α_3 is indeterminate. Positive α_3 implies crowding-in effect of public investment, while negative α_3 indicates crowding-out.

We further make two modifications to the model 1 expressed in equation (1). The pace of trade and financial sector liberalization in Bangladesh picked up in the early 1990s. Liberalization of trade may have some positive effect on private investment through the integration of the economy to the world market. Balasubramanyam, Salisu and Sapsford (1997) argue that an economy highly integrated to the world economy is expected to attract investment in tradable sectors. On the other hand, the liberalization of financial sector can stimulate domestic saving and make the credit flow to the private sector easier, which can play a supportive role to finance private investment. Hence, we introduce a dummy variable (lib) into the model for the year of significant trade and financial liberalization. This gives an augmented function for private investment of the form:

$$\text{Model 2:} \qquad PI_t=\alpha_0+\alpha_1 Y_t+\alpha_2 R_t+\alpha_3 GI_t+\alpha_4 lib+\varepsilon_t \tag{2}$$

where α_4 is expected to be positive.

Second, the liberalization of trade and financial sector can affect the public investment elasticity of private investment, because in a liberalized environment, the same public investment may affect private investment in a different way. For example, as liberalization makes a favorable environment for private investment, same amount of public investment in infrastructure may encourage higher public investment during the post liberalization period. Such influence can be captured by introducing an

interaction term between liberalization and public investment (lib*GI). A large number of empirical studies (e.g., Rajan and Zingales (1998), Rajan and Zingales (2003), Castro, Clementi and MacDonald (2004), Santos-Paulino and Thirlwal (2004) Caprio, Laeven and Levine (2007), and Giuliano and Ruiz-Arranz (2009)) have used interaction term in their estimations. Thus:

$$\text{Model 3:} \qquad PI_t=\alpha_0+\alpha_1 Y_t+\alpha_2 R_t+\alpha_3 GI_t+\alpha_4 lib+\alpha_5 (lib*GI)_t+\varepsilon_t \qquad (3)$$

In order to ensure that interaction term is not proxy for public investment or liberalization, these variables also included in the regression separately. If $\alpha_5>0$, it implies that liberalization increases crowding-in effect (or mitigates crowding-out effect), while $\alpha_5<0$ indicates that liberalization reinforces crowding-out effects (or off-sets crowding-in effect).

4. Data and Methodology

Due to unavailability of quarterly data, we use annual data in this study spanning from 1981 to 2015. Nominal data on domestic private investment, public investment and GDP have been collected from the World Development Indicators (WDI) 2016. In WDI 2016, data on the breaks of total investment (particularly, public investment) are not available for Bangladesh for the period before 1981. This has constrained us to start our sample from 1981. Then we have calculated real private investment, real public investment and real GDP by deflating the nominal variables by GDP deflator. We have gathered data on weighted average lending rate from various issues of the Monthly Economic Trends published by Bangladesh Bank. Then, the real interest rate has been calculated by subtracting inflation (percentage change of GDP deflator) from the nominal lending rate. All variables are in their natural logarithmic form except the real interest rate. As Bangladesh has been liberalizing its trade regime extensively since 1992 (Hoque and Yusop 2010) and interest rates liberalization begins in the country since 1st April 1992 (Bangladesh Bank 1992: 8) we introduce a single dummy variable (lib) for liberalization in the model. This dummy variable takes value 1 for the year beginning from 1992 and 0 otherwise.

Before running any regression it is worthwhile to test the time series properties of the underlying data as Nelson and Plosser (1982) argue that most macroeconomic series have unit roots i.e., non-stationary. Regression of non-stationary series may lead to spurious result. Dickey-Fuller type tests are commonly used to check the stationarity of the time series. However, this type of tests has limitation in identifying structural break in data, if there is any. Perron (1989) points out that traditional unit root tests are biased toward not rejecting the null hypothesis of unit root in the presence of structural break(s) in the data. To overcome this shortcoming, Perron (1989) develops a unit root test for data with a single structural break assuming that the date of the break is known *a priori* and the test is constructed using this information.

However, Perron's (1989) assumption of known break date has been criticized by a number of studies, most notably by Christiano (1992) who asserts that the critical values employed with the test presumes the break date to be chosen exogenously, and yet most researchers select a break point based on an examination of the data and thus the asymptotic theory assumed will no longer hold choice of break date is in most cases correlated with data. Subsequently, Zivot and Andrews (1992.), Banarjee Lumsdaine and Stock (1992), Perron (1997), and Vogelsang and Perron (1998) develop unit root tests for data with structural break considering endogenous break point.

As mentioned earlier, during the period of late 1980s and early 1990s, Bangladesh economy went through reforms in the areas of trade and financial sectors. Therefore, there is a compelling reason to suspect that there might have structural break in its macroeconomic time series (Hassan and Salim, 2011). Hence, in this study, use Perron's (1997) test to check unit root in the series. Perron (1997) assumes two types of break dynamics - *Innovative Outlier* (IO) and *Additive Outlier* (AO) - depending on how quickly a break occurs in the series after a shock. IO model assumes that break occurs slowly, while AO model

assumes that break occurs immediately. In the present context, we use IO model as it is reasonable to believe that policy reforms do not cause sudden change in macroeconomic variables.

Then, we use the Autoregressive Distributed Lag (ARDL) bound testing approach to cointegration (developed by Pesaran and Shin (1999) and further extended by Pesaran, Shin and Smith (2001)) to examine the long run and short run relationships between private investment and other variables of the models including public investment. The ARDL bound testing approach to cointegration has a number of advantages over the traditional cointegration tests (e.g., Engle and Granger (1987) and Johansen and Juselius (1990)). Firstly, traditional cointegration tests require that all the variables must be integrated in the same order, while ARDL approach is applicable irrespective of whether the variables are purely I(0), purely I(1) or mutually integrated (Pesaran *et al.* 2001). Secondly, different variables can take different number of lags in ARDL model, while traditional cointegration tests require a uniform number of lags. Thirdly, the ARDL model generally provides unbiased estimates of the long run model and valid t-statistic even when some of the regressors are endogenous (Harris and Sollis, 2003: 18). Fourthly, ARDL bound test allows dummy variable in the model. Critical values for bound testing are still valid even in the presence of a dummy variable. Furthermore, the bounds testing approach estimates the long run and short run components of the model simultaneously, removing problems associated with omitted variables and autocorrelation (Narayan, 2004b).

The ARDL bound testing approach is based on the ordinary least square (OLS) estimation of a conditional unrestricted error correction model (ECM). According to this approach we can express equation (1) in the following form:

$$\Delta PI_t = \beta_0 + \sum_{i=1}^{p} \phi_i \Delta PI_{t-i} + \sum_{i=0}^{p} \theta_i \Delta Y_{t-i} + \sum_{i=0}^{p} \lambda_i \Delta GI_{t-i} + \sum_{i=0}^{p} \gamma_i \Delta R_{t-i} + \delta_1 PI_{t-1} + \delta_2 Y_{t-1} + \delta_3 GI_{t-1} + \delta_4 R_{t-1} + \varepsilon_t \qquad (4)$$

Where PI, Y, GI are natural logarithm of real private investment, real output measured by GDP, and real public investment respectively, R is real interest rate, Δ is first difference operator and *p* is the maximum number of lags.

The first step of the ARDL bound testing approach is to estimate equation (4) by OLS method and then perform Wald test or F-test for the joint significance of the coefficient of the lagged level variables of the model, where null hypothesis is H_0: $\delta_1 = \delta_2 = \delta_3 = \delta_4 = 0$ against the alternative hypothesis of H_1: $\delta_1 \neq \delta_2 \neq \delta_3 \neq \delta_4 \neq 0$. Pesaran *et al*. (2001) have developed two sets of critical values for F-test of which one set (the lower critical bound) assumes that all independent variables are I(0) and the other (the upper critical bound) assumes that all independent variables are I(1). If the estimated F-statistic exceeds their respective upper critical values, we conclude that there is an evidence of a long run relationship among the variables regardless the order of integration of the variables. If the calculate value of the F-statistic is smaller than the lower critical bound then the null hypothesis of no cointegration cannot be rejected. On the other hand, if the F-statistic lies between the bounds, inference cannot be drawn without knowing the order of integration of the underlying regressors.

The second step is to estimate the long run relationship. If there is an evidence of cointegration in the first step then following ARDL (*l, m, n, q*) long run model is estimated:

$$PI_t = \beta_1 + \sum_{i=1}^{l} \phi_{1i} PI_{t-i} + \sum_{i=0}^{m} \theta_{1i} Y_{t-i} + \sum_{i=0}^{n} \lambda_{1i} GI_{t-i} + \sum_{i=0}^{q} \gamma_{1i} R_{t-i} + \varepsilon_{1t} \qquad (5)$$

where *l, m, n* and *q* are optimal number of lags of the variables and other variables are previously defined.

Finally, in the third step, the ARDL specification of the short run dynamics can be derived by constructing an error correction model (ECM) of the following form:

$$\Delta PI_t = \beta_2 + \sum_{i=1}^{p} \phi_{2i}\Delta PI_{t-i} + \sum_{i=0}^{p} \theta_{2i}\Delta Y_{t-i} + \sum_{i=0}^{p} \lambda_{2i}\Delta GI_{t-i} + \sum_{i=0}^{p} \gamma_{2i}\Delta R_{t-i} + \Psi ECM_{t-1} + \varepsilon_{2t} \quad (6)$$

Where ECM_{t-1} is the error correction term and is defined as:

$$ECM_t = PI_t - \beta_1 - \sum_{i=1}^{l} \phi_{1i}PI_{t-i} - \sum_{i=0}^{m} \theta_{1i}Y_{t-i} - \sum_{i=0}^{n} \lambda_{1i}GI_{t-i} - \sum_{i=0}^{q} \gamma_{1i}R_{t-i} \quad (7)$$

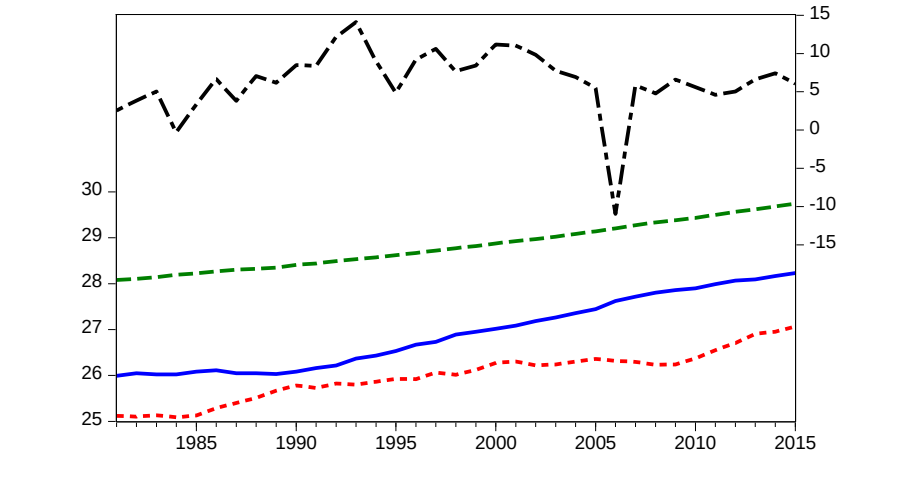
All the coefficients of the equation (6) represent the short run dynamics of the of the model's convergence to the equilibrium and Ψ represents the speed of adjustment.

Moreover, we can extend the abovementioned ARDL model for models described in equation (2) and (3) by incorporating dummy variable, as critical values for bound testing are valid even in the presence of a dummy variable.

5. Estimation and Results

In the first step, we conduct the unit root tests of the variables for two reasons: (i) to determine the appropriate method of cointegration test to follow. Johansen or Engle-Granger cointegration method cannot be used in the presence of a mixture of I(0) and I(1) variables. In that case, ARDL approach to cointegration is the appropriate one. (ii) To determine whether any variable is I(2), as ARDL model cannot be used in the presence of I(2) variable. The results of the unit root test (presented in Table I) suggest that real private investment (PI) and real GDP (Y) are I(1), while real public investment (GI) and real interest rate (R) are I(0). The existence of a mixture of I(0) and I(1) regressors justify the use of the ARDL model.

Figure 2: Trends of Private Investment, Public Investment, GDP, and Interest Rate



Source: World Development Indicators 2016 and
Monthly Economic Trends (various issues), Bangladesh Bank

Table 1: Perron (1997) Unit Root Test

Series	Lags	Break date	T-ratio	Result
PI	6	1992	-1.68	I(1)
ΔPI	0	1983	-6.34***	
Y	4	1987	-3.69	I(1)
ΔY	0	1996	-5.91***	
GI	3	2006	-6.93***	I(0)
R	0	2006	-7.17***	I(0)

Note: The null hypothesis states that the variable has a unit root. Lag lengths are based on the Schwarz Bayesian Criterion (SBC). Δ is the first difference operator. *** denotes significant at 1% level.

Next, to perform the ARDL bound test, we estimate the conditional unrestricted ECM for three different models described in equation (1), (2) and (3) with one and two lags for each model[2]. Table 2 presents the calculated F-values for the bound test, critical value bounds at different significance levels and the values of the Akaike Information Criterion (AIC) and the Schwarz Bayesian Criterion (SBC) for both lags of each model. Test results indicate that null hypothesis of no level relationship can be rejected at conventional significance levels for three models, irrespective of number of lags. Therefore, we conclude that variables are cointegrated and hence there exists long run relationship between private investment and regressors of the models for both lags. Since all models give minimum value of the AIC and the SBC for lag two, we choose two as the maximum number of lags for this study.

Table 2: Cointegration Tests for the Existence of a Long run Relationship

	Equation (1)		Equation (2)		Equation (3)		Significance Level	Critical Value Bounds	
Test Statistic	Lag1	Lag 2	Lag 1	Lag 2	Lag 1	Lag 2		I(0)	I(1)
F-statistic	5.88	3.98	7.05	6.00	10.40	6.96	1%	4.29	5.61
							5%	3.23	4.35
Lag Length Selection Criteria							10%	2.72	3.77
AIC	-2.75	-3.17	-2.86	-3.33	-3.07	-3.40			
SBC	-2.44	-2.73	-2.50	-2.88	-2.67	-2.91			

Note: Critical Values are based on Pesaran *et al.* (2001) for the case of unrestricted intercept and no trend.

Since there is an evidence of cointegration, in the next step we proceed to unveil the long run relationship and short run dynamics for equation (1), (2) and (3). Before estimating the long run relationship and short run dynamics, it is necessary to determine the appropriate lag structure for the models. The optimal number of lags for each variable of the ARDL model can be selected by using any of the Akaike Information Criteria (AIC), the Schwarz Bayesian Criterion (SBC) or the Hannan-Quinn criterion (HQC). Though the AIC and the SBC have very similar small-sample performance, however the performance of the SBC is slightly better in the majority of the experiments (Pesaran and Shin 1999). Hence, we choose the SBC to select the lag structure for the variables of the models. The estimates of the long run relationship and short run dynamics are presented in Table 3.

[2] For annual data, Pesaran and Shin (1999), Narayan and Smyth (2006) and Duasa (2007) use two as maximum number of lags.

Table 3: Estimates of the Long run and Short run Models

Dependent variable:	Coefficient		
Private investment (PI)	Equation 1	Equation 2	Equation 3
Long run Relationship			
Constant	-20.165*** (-8.49)	-14.561*** (-6.64)	-9.281*** (-2.65)
Y	1.937*** (11.37)	1.775*** (10.44)	1.682*** (11.16)
GI	-0.334** (-2.11)	-0.374** (-2.19)	-0.478*** (-3.23)
R	-0.002 (-0.30)	-0.017** (-2.03)	-0.013* (-1.96)
Liberalization Dummy (lib)	-	0.243** (2.41)	-6.752* (1.92)
Interaction (lib*GI)	-	-	0.272* (1.97)
Short run Dynamics			
ΔPI (-1)	0.405*** (4.20)	0.386***(4.16)	0.330*** (3.51)
ΔY	2.242** (2.31)	0.728*** (3.53)	0.810*** (4.00)
ΔY (-1)	-1.682* (1.74)	-	-
ΔGI	-0.598*** (-6.11)	-0.487*** (-5.17)	-0.554*** (-5.70)
ΔG (-1)	0.260** (2.40)	0.376*** (3.46)	0.315*** (2.88)
ΔR	-0.001 (-0.29)	-0.003 (-1.32)	-0.003 (1.25)
Liberalization Dummy (lib)	-	0.100*** (3.17)	-3.251* (1.77)
Interaction (lib*GI)	-	-	0.131* (1.83)
ECT (-1)	-0.401*** (-3.58)	-0.410***(-4.10)	-0.481*** (-4.66)
Diagnostic Checks			
R^2-Adjusted	0.81	0.83	0.85
Serial Correlation LM Test	$\chi^2(1)$: 1.89 [0.17] $\chi^2(2)$: 2.33 [0.31]	$\chi^2(1)$: 0.56 [0.45], $\chi^2(2)$: 0.74 [0.69]	$\chi^2(1)$:1.29 [0.26] $\chi^2(2)$: 1.29 [0.53]
ARCH Test	$\chi2(1)$: 0.52 [0.47] $\chi2(2)$: 1.09 [0.58]	$\chi2(1)$: 0.21 [0.65] $\chi2(2)$: 0.86 [0.65]	$\chi2(1)$:0.86[0.35] $\chi2(2)$:3.98 [0.14]
Normality (Jarque-Bera) Test	$\chi^2(2)$: 0.14 [0.93]	$\chi^2(2)$: 0.25 [0.88]	$\chi^2(2)$: 1.25 [0.54]

Note: Δ is the first difference operator. ECT (-1) indicates error correction term. Values in () and [] are t-statistics and p-value respectively. *, **and *** denote significant at 10%, 5% and 1% respectively

The results of the long run estimation show that aggregate output has a positive and significant effect on private investment across all equations, while public investment exerts a negative effect on private investment in Bangladesh. The coefficient of aggregate output ranges from 1.68 to 1.94 which is consistent with the findings of Majumder (2007) (1.35), Ang (2010) (1.34-1.53), Hassan and Salim (2011) (1.81), and Sahu and Panda (2012) (1.63). The negative coefficient of public investment indicates that public investment crowds-out private investment. The coefficient of public investment lies between -0.33 and -0.48 which supports the findings of Hassan and Salim (2011) study (-0.21), however, contradicts Majumder (2007) who found crowding-in effect in Bangladesh.

In equation (2), the coefficient of the liberalization dummy (lib) is positive (0.24) though significant at 10% level. This implies that liberalization facilitates private investment in Bangladesh. In equation (3), the coefficient of the interaction between liberalization and public investment (lib*GI) is significant and positive (0.27) which corroborates that public investment has different effects on private investment during the post liberalization period[3]. This result suggests that liberalization not only affects

[3] The effect of public investment on private investment during the pre and post liberalization period can be obtained by differentiating equation (3) with respect to public investment:

private investment directly but also affects indirectly, by influencing the relationship between public and private investment. The positive coefficient of the interaction term (lib*GI) implies that crowding-out effect of public investment is partially mitigated by the effect of liberalization.

In equation (3), although the liberalization dummy has a negative coefficient, nonetheless, total effect of liberalization is positive (0.32) and is slightly higher than the effect of liberalization in equation (2)[4]. Real interest rate exerts significant negative effect on private investment in equation (2) and (3) although the coefficient is very small in magnitude (-0.02 and -0.01 respectively). This variable, however, has no significant effect on private investment if the liberalization variable is excluded from the model (Equation 1). The significant positive impact of aggregate output and negative impact of real interest rate on private investment support the flexible accelerator model. Moreover, the results of the long run model suggest that aggregate output is the most crucial determinant of private investment in Bangladesh.

The middle part of Table 3 presents the short run dynamic of the models. All short run coefficients are significant, except the real interest rate. Real interest has no significant effect on private investment in any model. The error correction terms (the speed of adjustment) are reasonably large in all models (ranges from -0.40 to -0.48) and highly significant (at 1% level) with the correct sign, indicating that the system takes approximately 2 - 2.5 years to return to the long run equilibrium once it is disturbed.

In the short run, public investment (ΔG) has a relatively large instantaneous negative effect on private investment (the coefficient, which ranges between -0.49 and -0.60, is larger than its long run counterpart). However, over time, the impact of public investment on private investment turns to be positive from instantaneous negative effect which is reflected in the significant positive coefficient of lagged difference of public investment ($\Delta GI(-1)$) (although the coefficients, which ranges from 0.26 to 0.38, is relatively small). One of the reasons behind such behavior might be that positive impact of public investment in infrastructure comes with a lag. As a result, some part of the crowding-out is being canceled out by the positive impact of lagged public investment and crowding-out becomes moderate in the long run.

Similar to the long run, the coefficient of aggregate output is positive and highly significant in the short run. However, in equation (1), output (ΔY) has extraordinarily large instantaneous effect on private investment, which is partially canceled out by the negative effect of lagged difference output ($\Delta Y(-1)$). The coefficients of lagged difference private investment ($\Delta PI(-1)$) is positive and significant, implying that private investment has a memory effect. Liberalization dummy and interaction term also have significant positive coefficient in the short run, although coefficients are relatively small in magnitude.

The lower part of Table 3 represents a battery of diagnostic tests of the estimated models along with adjusted-R^2s of the models. The estimated equations fit reasonably well (as adjusted-R^2 is greater than 80%) and the regressions show an improvement if we move from equation (1) to (3) (as adjusted-R^2 increases). The estimated models pass the diagnostic tests against residual serial correlation, heteroscedasticity (ARCH) and non-normality problem. Moreover, recursive estimation of the conditional ECM and plots of the associated cumulative sum (CUSUM) and cumulative sum of squared (CUSUM of Squares) residuals also suggest that the regression coefficients are generally stable over the sample period (Figure A.1 in Appendix).

For the post liberalization period: $\frac{\partial PI}{\partial (GI)} = -0.48 + 0.27*lib$

$= -0.48+0.27= -0.21$ (as lib=1 for the post liberalization period)

For the pre liberalization period: $\frac{\partial PI}{\partial (GI)} = -0.48 + 0.27*0= -0.48$ (as lib=0 for the pre liberalization period)

[4] In equation (3), the total effect of liberalization dummy on private investment is 0.32 which can be found by differentiating equation (3) with respect to lib. $\frac{\partial PI}{\partial (lib)} = -6.752 + 0.272*GI = -6.752 + 0.272*25.99= 0.319$

where 25.99 is the mean value of log public investment over the period 1981-2015.

6. Analysis of the Results

The results of the study suggest that public investment has a crowding-out effect on private investment. This paper, however, deserves an explanation about the channels of the crowding-out. Originally the concept of crowding-out is related to the increase in interest rates resulting from domestic borrowing by the government. The results of the study suggest that 1% increase in public investment decreases 0.33%–0.48% private investment in the long run, while 1% increase in real interest rate leads to 0.01%–0.02% decrease in private investment. Since private investment is weakly sensitive to interest rate, interest rate cannot be the only channel of crowding out; there might be some other channel of crowding-out.

Blejer and Khan (1984), Ramirez (1994) and Erden and Holcombe (2005) assert that one of the principal constraints on investment in developing countries is quantity (availability of credit), rather than cost of financial resources. Emran and Farazi (2009) also argue that if the interest rates are not determined by the market clearing forces, then the quantity channel would be more significant in understanding the effects of government borrowings on private investment.

As the credit market of Bangladesh is distorted in many ways (e.g., directed credit disbursements, central bank's intervention in interest rates determination for selective sectors, asymmetric information, high interest rate of government saving certifies compared to formal credit market, existence of large informal credit market parallel to the formal credit market etc.), quantity channel might have a large role in explaining crowding-out[5]. In Bangladesh, when government expenditure rises, government borrows more from the banking system and/or sells savings certificates to finance its deficit budget, which in turn reduces the availability of funds for the private sector and leads to crowding out of private investment.

7. Conclusion

The central aim of this paper is to investigate whether public investment crowds out or crowds in private investment in Bangladesh. To test this hypothesis, we have used annual data on real private investment, real public investment, real GDP and real interest rate over the period 1981-2015 in a bound testing approach to cointegration within the ARDL framework. As the Bangladesh economy has gone through a major policy change in the early 1990s by liberalization of trade and financial sectors, we have also examined if there is any discernible effect of liberalization on the relationship between public and private investment. Hence, we have included a dummy variable for liberalization and an interaction term of liberalization and public investment in the model. The empirical results of three different models show that variables are cointegrated and public investment has a significant crowding-out effect on private investment both in the long run and short run. Real output has significant and strong positive effect on private investment both in the long run and short run, while the real interest rate affects private investment negatively in the long run. Moreover, the interaction term between public investment and liberalization has a significant coefficient which implies that public investment has a different effect on private investment in the post liberalization period. The positive coefficient of the interaction term indicates that the crowding-out effect decreases in the post liberalization period.

In recent years, the government of Bangladesh has been emphasizing on public investment to attain higher GDP growth. In such a situation, the findings of the study have important implications for both monetary and fiscal policy formulation. First, the key finding of this study is that public investment adversely affects private investment in Bangladesh. This result might suggest that a large chunk of public investment has gone towards unproductive or consumption investment rather than capital of productive investment. Therefore, it will be imperative for the fiscal authority to select those public investment

[5] Initially, we have also included credit to private sector in the model as an explanatory variable. We, however, find that no model passes the bound test in the presence of the credit to private sector variable (results of the test have not been reported in this paper but can be obtained from the authors on request). For this reason, we have dropped the variable from the models.

projects which have greater productivity enhancing effect, higher social return and spillover effects. Second, given the finding of low interest rate sensitivity of private investment, interest rate channel of monetary policy seems to be moderately effective in Bangladesh. Therefore, reduction of interest rate may not be an appropriate policy for monetary authority to increase private investment during economic down-turn. In that situation, ensuring credit supply for the private sector can be an effective policy. Hence, while policies are aimed at increasing public investment to accelerate economic growth rate, policymakers should pay attention to the availability of sufficient credit for private sector. Third, as economic liberalization dampens the crowding out effect of public investment, Bangladesh can reap more benefit from public investment by removing the impediments to trade openness and financial deregulation.

References

Ang, James B. (2010) "Determinants of Private Investment in Malaysia: What Causes the Post crisis Slumps" *Contemporary Economic Policy*, 28(3), 378-391

Argimon, Isabel, Jose M. Gonzalez-Paramo and Jose M. Roldan (1997) "Evidence of Public Spending Crowding-out from a Panel of OECD Countries" *Applied Economics* 29(8), 1001-1010

Aschauer, David Alan (1989) "Does Public Capital Crowd out Private Capital?" *Journal of Monetary Economics* 24, 171-188

Balasubramanyam, V. N., M. Salisu and David Sapsford (1996) "Foreign Direct Investment and Growth in EP and IS Countries", *The Economic Journal*, 106, 92-105

Banerjee, Anindya, Robin L. Lumsdaine, and James H. Stock (1992) "Recursive and Sequential Tests of the Unit-Root and Trend-Break Hypotheses: Theory and International Evidence," *Journal of Business & Economic Statistics*, 10, 271–287

Bangladesh Bank (1992) *Bangladesh Bank Annual Report 1991-92*, Bangladesh Bank

Blejer, Mario I. and Mohsin S. Khan (2004) "Government Policy and Private Investment in Developing Countries" *IMF Staff Papers* 31(2), 379-403

Caprio, Gerard, Luc Laeven and Ross Levine (2007) "Governance and Bank Valuation" *Journal of Financial Intermediation*, 16(4), 584-617

Castro, Rui, Gian L. Clementi and Glenn MacDonald (2004) "Investor Protection, Optimal Incentives, and Economic Growth", *Quarterly Journal of Ecnimics*, 119(3), 1131-1175

Cavallo, Eduardo and Christian Daude (2011) "Public investment in developing countries: A blessing or a curse?" *Journal of Comparative Economics* 39, 65–81

Chirinko, Robert S. (1993) "Business fixed investment spending: Modeling strategies, Empirical Results, and Policy Implications", *Journal of Economic Literature*, 31(4), 1875-1911

Christiano, L. J. (1992) "Searching for a Break in GNP", *Journal of Business and Economic Statistics*, 10, 237-250

Duasa, Jarita (2007) "Determinants of Malaysian trade balance: An ARDL bound testing approach." *Global Economic Review*, 36(1), 89-102

Emran, M. Shahe and Subika Farazi (2009) "Lazy Bank? Government Borrowing and Private Credit in Developing Countries" IIEP-WP-2009-9, Institute for International Economic Policy Working Paper Series, Elliot School of International Affairs, The Gorge Washington University

Engle, Robert F. and C. W. J. Granger (1987) "Cointegration and Error Correction: Representation, Estimation, and Testing", *Econometrica*, 55(2), 251-276

Erden, Lutfi and Randall G. Holcombe (2005) "The Effects of Public Investment on Private Investment in Developing Countries" *Public Finance Review* 33(5), 575-602

Giuliano, Paola and M. Ruiz-Arranz (2009) "Remittances, financial Development, and Growth". *Journal of Development Economics*, 90, 144-152

Harris, R. and Sollis, R. (2003) *Applied Time Series Modelling and Forecasting*, West Sussex: Wiley

Hassan, A.F.M. Kamrul and Ruhul A. Salim (2011) "Determinants of Private Investment: Time Series Evidence from Bangladesh", *The Journal of Developing Areas*, Fall, 229-249

Hatano, Toshiya (2010) "Crowding-in Effect of Public Investment on Private Investment" *Public Policy Review* 6(1), 105-120

Hoque, Mohammad Monjurul and Zulkornain Yusop (2010) "Impacts of trade liberalisation on aggregate import in Bangladesh: An ARDL Bounds test approach" *Journal of Asian Economics* 21(1), 37-52

Hyder, Kalim (2001) "Crowding-out Hypothesis in a Vector Error Correction Framework: A Case Study of Pakistan" *The Pakistan Development Review* 40(4), 633-650

Johansen, Soren and Katarina Juselius (1990) "Maximum Likelihood Estimation and Inference on Cointegration with Application to the Demand for Money" *Oxford Bulletin of Economics and Statistics* 52 (2), 169–210

Khan, Azizur Rahman, and Mahabub Hossain (1989) *The Strategy of Development in Bangladesh.* London: Macmillan

Majumder, Alauddin Md. (2007) "Does Public Borrowing Crowd-out Private Investment? The Bangladesh Evidence" Working Paper Series: WP 708, Policy Analysis Unit, Bangladesh Bank

Mankiw, Gregory N. (2009) *Macroeconomics,* 7th ed., Worth Publishers: New York

Martinez-Lopez, Diego (2006) "Linking Public Investment to Private Investment. The case of Spanish Regions" *International Review of Applied Economics* 20(4), 411-423

Mitra, Pritha (2006) "Has Government Investment Crowded out Private investment?" *American Economic Review* 96(2), 337-341

Muhith, AMA. 1999. *Bangladesh in the Twenty-First Century: Towards and Industrial Society*. Dhaka: The University Press Limited

Narayan, Paresh Kumar (2004a) "Do public investments crowd out private investments? Fresh evidence from Fiji" *Journal of Policy Modeling* 26, 747–753

———. (2004b) "Reformulating Critical Values for the Bounds F-statistics Approach to Cointegration: An Application to the Tourism Demand Model for Fiji" Monash University. No. 02/04

Narayan,Paresh Kumar and Russell Smyth (2006) "Dead man Walking: An Empirical Reassessment of the Deterrent Effect of Capital Punishment Using the Bounds Testing Approach to Cointegration" *Applied Economics* 38(17), 1975-1989

Nelson, Charles R. and Charles I. Plosser (1982) "Trends and Random Walks in Macroeconomic Timeseries", *Journal of Monetary Economics*, 10, 139-162

Perron, Pierre (1989) "The Great Crash, the Oil Price Shock, and the Unit Root Hypothesis," *Econometrica*, 57, 1361-1401

Perron, Pierre (1997) "Further Evidence on Breaking Trend Functions in Macroeconomic Variables," *Journal of Econometrics*, 80, 355–385

Pesaran, M. Hashem, Yongcheol Shin (1999) "Autoregressive Distributed Lag Modelling Approach to Cointegration Analysis" in *Econometrics and Economic theory in the 20th Century: the Ragnar Frisch Centennial Symposium*, by Strom, Steinar, Eds., Cambridge University Press: Cambridge

Pesaran, M. Hashem, Yongcheol Shin and Richard J. Smith (2001) "Bounds Testing Approaches to the Analysis of Level Relationships" *Journal of Applied Econometrics* 16 (3), 289-326

Planning Commission (2015) "*The Seventh Five year Plan FY2016-FY2020*" Ministry of Planning, The Govt. of the Peoples' Republic of Bangladesh, Dhaka

Rajan, Raghuram G. and Luigi Zingales (1998) "Financial Dependence and Growth", *American Economic Review*, 88(3), 559-586

Rajan, Raghuram G. and Luigi Zingales (2003) "The Great Reversals: The Politics of Financial Development in the Twentieth Century", *Journal of Financial Economics*, 69, 5-50

Ramirez, Miguel D. (1994) "Public and private investment in Mexico, 1950-90: An empirical analysis" *Southern Economic Journal* 61 (1), 1-17

Sahu, Jagadish Prasad and Sitakanta Panda (2012) "Is Private Investment Being Crowded out in India? Some Fresh Evidence" *Economics Bulletin* 32(2), 1125-1132

Santos-Paulino, Amelia and A. P. Thirlwall (2004) "The Impact of Trade Liberalization in Exports, Imports and the Balance of Payment of Developing Countries" *The Economic Journal*, 114, 50-72

Vogelsang, Timothy J. and Pierre Perron (1998) "Additional Test for Unit Root Allowing for a Break in theTrend Function at an Unknown Time," *International Economic Review*, 39, 1073–1100

Voss, Graham M. (2002) "Public and Private Investment in the United States and Canada" *Economic Modelling* 19, 641-664

World Bank (1995) "Bangladesh: From Stabilization to Growth". The World Bank, Washington, D.C

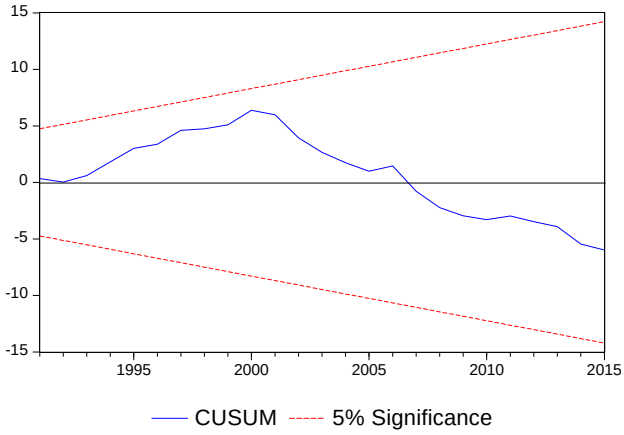
World Bank (1999) "Bangladesh Trade Liberalization: Its Pace and Impacts". The World Bank, Washington, D.C

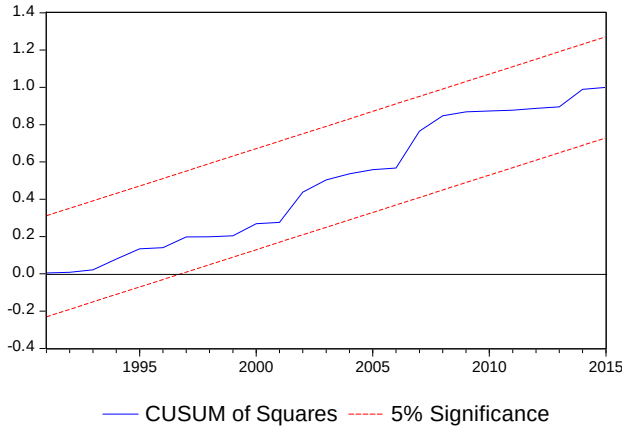
Zivot, Eric and Donald W. K. Andrews (1992) "Further Evidence on the Great Crash, the Oil-Price Shock, and the Unit-Root Hypothesis," *Journal of Business & Economic Statistics*, 10, 251–270

Appendix

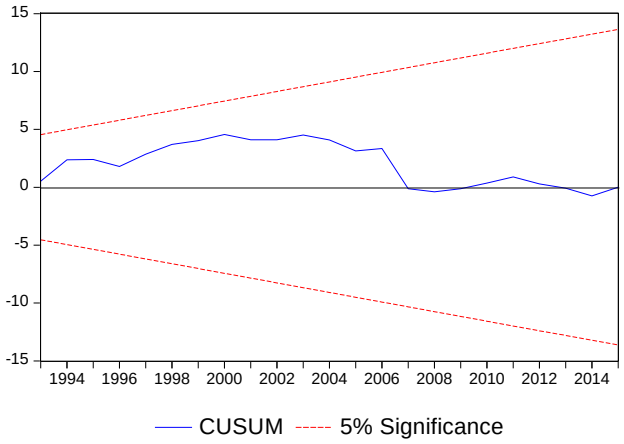
Figure A.1: CUSUM and CUSUM of Squares of Recursive Residuals

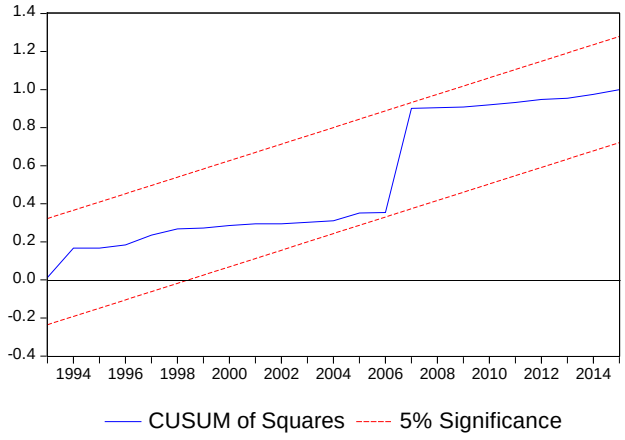
Model 1





Model 2





Model 3