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A Cointegration Analysis of Investment Output Ratio in Bangladesh

Emmanuel Anoruo[1] Saten Kumar[2] and Bill DiPietro[3]

Abstract

In this article, we have estimated a neo-classical model of investment augmented with real rate of interest to proxy the user cost of capital for Bangladesh. Our results reveal that there is a equilibrium relationship between investment output ratio, real output and real rate of interest. The long run relationship persists even in the presence of structural breaks in the model.

JEL classification: E22; E62; R34; O23; P41

Keywords: Investment Output Ratio, Johansen Maximum Likelihood Method and Gregory Hansen Structural Break tests.

1. Introduction

The importance of investment for economic growth and development of a nation has been at the heart of economics almost since its inception. From the various kinds of resources, Classical economics stressed the importance of capital formation for economic growth. Capital matters for the generation of economic output because it is a factor of production, because it embodies new technology, and because it is complementary to human capital. China's spectacular economic performance in recent years may be at least partially explained by its investment driven growth strategy and its high rate of capital

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formation. Keynes singled out investment as being critical for the economic stability. He saw fluctuations in business spending as the source of economic instability, and, postulated a negative relationship between investment and interest rates.

Given the importance of investment for growth and development, and for economic stability, this paper looks at the potential determinants of investment for the both the short-run and the long-run for an economy in the throes of economic development, Bangladesh. Neoclassical investment theory maintains that profit-maximizing firms invest up to the point where the marginal productivity of capital equals the cost of capital. In the neoclassical world, anything that affects either the marginal productivity of capital or the cost of capital changes the steady state with higher marginal productivity increasing economic investment and greater capital cost lowering aggregate investment. It is obvious that profitability and the productivity of capital go hand in hand with business sales. Since business sales depend on the state of the economy, investment is expected to be positively related to overall economic output.

A major factor determining the cost of capital is the interest rate. The interest rate affects all three of the major components of investment, fixed investment, inventory investment, and residential investment. Higher interest rates reduce both fixed and inventory investment because it increases the opportunity cost of funneling money into these two investment channels. It also reduces residential investment by reducing the demand for housing, thereby lowering home prices and the profitability of investing in housing.

The traditional accelerator model ties investment, especially, inventory investment to changes in output. If, and this seems reasonable, desired inventories are a constant proportion of total output, then changes in inventories, inventory investment, will be positively related to the level of economic activity. These variables, as well as others, have been used in previous empirical studies attempting to explain the determinants of investment in both developed and developing countries. In their empirical piece, Greene and Villanueva (1991) find that, in developing countries, investment depends on changes in output. Bernanke (1983) criticizes the overemphasis on output, sales and profits (the marginal productivity side of the neoclassical ledger) as determinants of investment along with its associated under emphasis on capital cost items, such as the interest rate, as determinants of fixed investment. He finds, in his empirical analysis using annual aggregate data for the U.S. economy from 1947 to 1979, that, although returns to capital certainly are important for investment, the interest rate also really matters.

Oshikoya (1994) using pooled data for Cameroon, Mauritius, Morocco, Tunisia, Kenya, Malawi, and Tanzania for the period 1970 through 1980 regressed the ratio of private sector investment to GDP on a whole series of variables including the percentage change in GDP, the ratio of public sector investment to GDP, the change in credit to the private sector, and several variables that try to capture the degree of uncertainty in the economic environment. His finds that real output growth, credit availability, public sector investment in infrastructure, and macroeconomic stability are significant determinants of private investment in for the sample African countries. With regard to placating the interest in theoretical aspects surrounding investment, literature reviews of investment theory can be found in Clark (1979) and Jorgenson (1971).

The uniqueness of this paper is, first, that it is a case study of the determinants of investment in a truly developing country (Bangladesh's real GDP per capita for 2003 in constant 2000 U.S. dollars was only 382.dollars), second, that it applies new econometric techniques to look at the determinants of investment in both the short- and the long-run, and, third, that it looks at whether the long run investment function in Bangladesh is stable in the presence of structural breaks.

The organization of the paper is as follows. Section 2 explains the model and its specification. Section 3 details the empirical work and its findings, and section 4 provides a conclusion with some policy recommendations.

2. Model Specification

We specify the investment output ratio function based on the assumption that technology is flexible and investment depends on both output and the user cost of capital. The neo-classical investment theory assumes that

$$K^*_t = f\,(Y_t/UCK_t) = \alpha\,(Y_t/UCK_t) \qquad (1)$$

$$I_t = \Delta K_t + dK_{t-1} \qquad (2)$$

where K^* is the stock of capital at equilibrium, Y is real output, UCK is the user cost of capital, I is gross investment and d is the rate of depreciation. According to Solow (1956) the growth of capital stock comes to an end in the long run. This implies that the long run specification of investment is

$$I^*_t = \alpha d\ (Y_t/UCK_t) \qquad (3)$$

Using the above long run investment specification we can specify the short run dynamic equation as

$$\Delta \ln I_t = -\lambda[(\ln I_{t-1} - (\beta_1 \ln Y_{t-1} - \beta_2\, UCK_{t-1})]$$

$$+ \gamma_t \sum_{i=0}^{n1} \Delta \ln Y_{t-i} + \rho_t \sum_{j=0}^{n2} \Delta UCK_{t-j} + \varphi_t \sum_{m=0}^{n3} \Delta \ln I_{t-m} \qquad (4)$$

We ignore the assumption that output and user cost of capital have same elasticity. The crucial parameters β_1 and β_2 are the long run output elasticity and the semi-elasticity of the user cost of capital, respectively.

In developing countries the data on user cost of capital is not available. However, we have used the real rate of interest to proxy for the user cost of capital. The real rate of interest is computed as the difference between nominal long term interest rate and GDP deflator rate. The investment output ratio is estimated because it is an important policy variable. We computed the investment output ratio as real private investment divided by real GDP at factor cost.

3. Empirical Results:

Unit Root Tests

We first examine the time series properties of the variables viz., investment output ratio (ln (*I/Y*)), real output (ln*Y*) and real rate of interest (*R*) through the modified Dicky-Fuller test (DF-GLS test). The DF-GLS unit root tests have high power compared to standard ADF unit root tests. We applied DF-GLS tests for both levels and their first differences and the results are in Table 1 below:

Table 1: Modified Dicky-Fuller (DF-GLS) Unit Roots Tests

Variable	W	Test Statistic	95% CV
ln (*I/Y*)	1	-3.453	-3.954
Δ ln (*I/Y*)	1	-6.441*	-3.603
ln *Y*	4	-1.279	-3.594
Δln *Y*	2	-4.096*	-3.603
R	0	-1.853	-3.594
Δ*R*	2	-4.484*	-3.603

Notes: W is the lag length of the first differences of the variables.
* indicates significance at 5% level. The sample period is 1973-2004.

For the level variables that is ln (*I/Y*), ln *Y* and *R*, the null hypothesis of unit root cannot be rejected at the 5% level. Alternatively, the null that their first differences have unit roots is clearly rejected. Therefore, the level variables contain unit roots *I*(1) and their first differences are stationary *I*(0). Microfit 4.1 of Pesaran and Pesaran (1997) is used for all estimations. We used annual data from 1973 to 2004. Definitions of the variables and sources of data are in the Appendix.

The Johansen Approach

In what follows we detail our results obtained with the Johansen Maximum Likelihood (JML) technique. We subjected the investment ratio, real output and user cost of capital in a VAR(4) framework to Johansen tests.[3] Using unrestricted intercept and unrestricted trend option, the maximal eigenvalue and trace test statistics for the null hypothesis that there is no cointegration are 36.949 and 56.163, respectively. The 95%

[3] The Akaike Information Criteria (AIC) and Schwartz Bayesian Criteria (SBC) criteria were used to select the lag length of the VAR and both indicated lag length of 4 periods.

critical values, respectively, are 24.350 and 39.330. For the null hypothesis that there is one cointegrating vector, the corresponding computed values, with the critical values in the parentheses are 15.043 (18.330) and 17.194 (23.830), respectively. Both the eigenvalue and the trace statistics rejected the null hypothesis of no cointegration, but the null hypothesis that there is at least one long run relationship is not rejected. Therefore, the implied cointegrating vector (CV) normalized on the investment output ratio is:

$$\ln (I/Y)_t = \underset{(4.78)}{0.970^*} \ln Y_t - \underset{(2.29)}{0.067^*} R_t \qquad (5)$$

The absolute *t*-ratios are in the parentheses and * imply significance at 5 percent level. Equation (5) implies that the output elasticity is around unity and the real interest rate elasticity at its mean rate of 4.48% is around -0.3. These crucial elasticities are significant with the expected signs.

We also tested for the identification and endogeinity as given by Rao (2006) and Enders (2004). For identification tests, we found that the cointegrating vector represents long run investment output ratio function. Alternatively, the cointegrating vectors normalized on real output and the user cost of capital were insignificant in their respective regressions. Further, for endogeinity tests three different ECM equations were estimated. In each of the implied equation, the one period lagged residual of investment output ratio is included as one of the independent variables. We found that the residual term for investment output ratio is only significant with the correct negative sign in the equation where the dependent variable is $\Delta\ln(I/Y)_t$. Therefore, we can treat $\ln Y_t$ and R_t as being weakly exogenous variables. The identification and endogeinity test results are in Table-1A of the Appendix.

The Gregory Hansen Tests

The Johansen cointegration tests do not account for structural breaks in the data. In addition, a number of studies including Wu (1998) and Lau and Baharumshah (2003) several studies have shown that the Johansen cointegration procedures are sensitive to structural breaks. Therefore, this study applies the Gregory-Hansen cointegration procedures to investigate the existence of long run relationship between investment output ratio, real output and real interest rate. Gregory and Hansen (1996) developed residual based tests for the null hypothesis of no cointegration with structural breaks against the alternative of cointegration. The structural break in the data is endogenously determined within the model. The three models under the Gregory-Hansen cointegration tests and their alternative assumptions about structural breaks are as follows:

Model 1: Level Shift
Model 2: level shift with trend
Model 3: Regime shift (Intercept and the slope coefficients change)

Table 2: Cointegration Tests with Structural Breaks

	Break Year	GH Test Statistic	5% Critical Value	H_0 of no Cointegration
Model 1	1985	-4.233	-3.02	Reject
Model 2	1987	-7.290	-6.67	Reject
Model 3	1987	-4.715	-3.53	Reject

Table 2 presents the results obtained from the three models of the Gregory-Hansen tests. The results reveal that the null hypothesis of no cointegration between investment output ratio, real output and real interest rate should be rejected at the 5 percent level of significance. In each case the computed test statistic exceeds the critical value at the 5 percent level. For example, in model test statistic (-4.233) is greater the 5 percent critical value (-3.02). The results from the Gregory-Hansen procedures corroborate those obtained from the Johansen cointegration tests. It is noteworthy that the endogenously determined break year is 1985 in Model 1 and 1987 in Models 2 and 3. Taken together, the results from the various cointegration tests implemented by the study suggest that is a long run equilibrium relationship between investment output ratio, real output and real interest rate.

Having established the existence of cointegration between investment output ratio, real output and real interest rate, the study next formulates an ECM to determine the short- and long- run interactions between investment output ratio, real output and real interest rate. In estimating the dynamic investment output ratio equation, the study included the error term (residual of investment output ratio) as one of the independent variables and applied the General to Specific philosophy in the second stage of estimation. Using lags of 4 periods and through the variable deletion tests we arrived at the following parsimonious equation:[4]

[4] The absolute *t*-ratios are below the estimated coefficients. * and ** indicate significance at the 5% and 10% levels, respectively. $\Delta^2 \ln P$ represents the growth in expected inflation. The dummy variable *DUM* captures the effects of financial reforms and deregulation in Bangladesh. *DUM* is constructed as 1 from 1985-1990 and zero otherwise.

$$\Delta \ln (I/Y)_t = -3.218^* - 0.529^*\, ECM_{t-1} - 0.241^{**}\, \Delta \ln (I/Y)_{t-2} - 7.634^*\, \Delta \ln Y_{t-1}$$
$$(4.18) \quad (4.27) \quad (1.95) \quad (3.88)$$
$$+\, 3.947^*\, \Delta \ln Y_{t-3} - 3.940^*\, \Delta R_t + 1.703^*\, \Delta R_{t-1} - 0.882^*\, \Delta^2 \ln P_{t-1}$$
$$(3.13) \quad (5.47) \quad (2.67) \quad (2.29)$$
$$-\, 0.747^*\, \Delta^2 \ln P_{t-2} - 0.645^*\, \Delta^2 \ln P_{t-3} + 0.063^*\, DUM$$
$$(2.86) \quad (3.03) \quad (2.66)$$

$\bar{R}^2 = 0.692$, $SER = 0.099$, *Period*: 1978-2003 (6)

$X^2_{sc1} = 0.767\ (0.38)$, $X^2_{ff} = 0.019\ (0.89)$,
$X^2_{n} = 1.019\ (0.60)$, $X^2_{hs} = 0.188\ (0.67)$

It may be noted from these estimates that it is possible to impose parameter restrictions to raise the degrees of freedom. The regression coefficients on $\Delta \ln Y_{t-3}$ and ΔR_t are close and opposite in sign. When this restriction is tested, the Wald test computed $\chi^2(1)$ test statistic with the *p*- value in the parenthesis is 0.003 (0.996) is insignificant and the constraint could not be rejected. Likewise, the coefficients of $\Delta^2 \ln P_{t-1}$, $\Delta^2 \ln P_{t-2}$ and $\Delta^2 \ln P_{t-3}$ are close and the restriction could not be rejected because the $\chi^2(1)$ test statistic with *p*- value in the parenthesis is 2.034 (0.154) is insignificant. The following ultra parsimonious equation is based on these restrictions:

$$\Delta \ln (I/Y)_t = -2.950^* - 0.481^*\, ECM_{t-1} - 0.252^{**}\, \Delta \ln (I/Y)_{t-2} - 6.658^*\, \Delta \ln Y_{t-1}$$
$$(4.90) \quad (5.08) \quad (2.28) \quad (4.87)$$
$$+\, 3.840^*\, \Delta \ln Y_{t-3} - 3.840^*\, \Delta R_t + 1.362^*\, \Delta R_{t-1} - 0.628^*\, \Delta^2 \ln P_{t-1}$$
$$(5.99) \quad (c) \quad (3.22) \quad (3.38)$$
$$-\, 0.628^*\, \Delta^2 \ln P_{t-2} - 0.628^*\, \Delta^2 \ln P_{t-3} + 0.053^*\, DUM$$
$$(c) \quad (c) \quad (2.42)$$

$$\bar{R}^2 = 0.732, \quad SER = 0.093, \quad Period\text{: 1978-2003} \qquad (7)$$
$$X^2_{sc1} = 0.693\ (0.41),\ X^2_{ff} = 0.561\ (0.45),$$
$$X^2_{n} = 3.461\ (0.18),\ X^2_{hs} = 0.081\ (0.78)$$

In Equation (7) the coefficient of the lagged error term (ECM_{t-1}) is significant and has the expected negative sign. This implies that departures from equilibrium in the previous period are reduced by about 48% in the subsequent period. The regression coefficient on change in expected inflation ($\Delta^2 \ln P_t$) is significant and implies that it has temporary negative impact on investment output ratio. The *DUM* dummy variable is also significant and has temporary positive effect on investment output ratio. The χ^2 summary statistics are also reasonable.

To shed additional light on the relationship between investment output ratio, real output and real interest rate, study applies structural instability tests including the *CUSUM* and the *CUSUMSQ* procedures developed by Brown et al. (1975). The CUSUM procedure is based on the cumulative recursive sum of recursive residuals. However, the CUSUMSQ framework is based on the cumulative sum of squares of recursive residuals. To draw inferences relative to the stability of the parameters and the model in particular, the CUSUM and the CUSUMSQ procedures are updated recursively and are plotted against the break points.

The null hypothesis of instability is rejected when the plots of the CUSUM and the CUSUMSQ stay within the 5 percent significance level. However, the model is unstable when the plots of the CUSUM and the CUSUMSQ move outside the 5 percent critical lines. Both the *CUSUM* and the *CUSUMSQ* instability tests were applied to

Equation (7). Figures 1 and 2 display the plots of the CUSUM and the CUSUMSQ, respectively. As can be seen from the Figures, the plots for both the CUSUM and the CUSUMSQ remained within the 5 percent critical bounds. This finding suggests the model is stable.

Figure 1: Plot of CUSUM Tests for Equation (7)

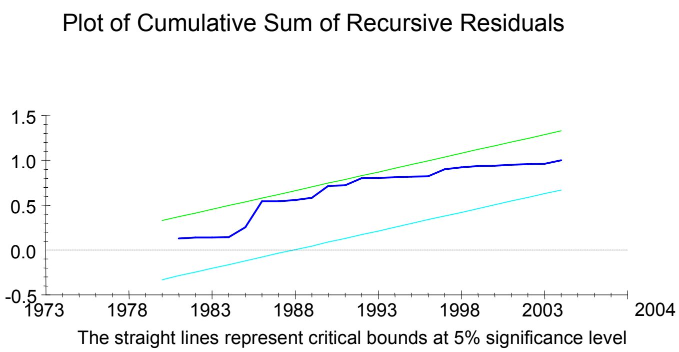
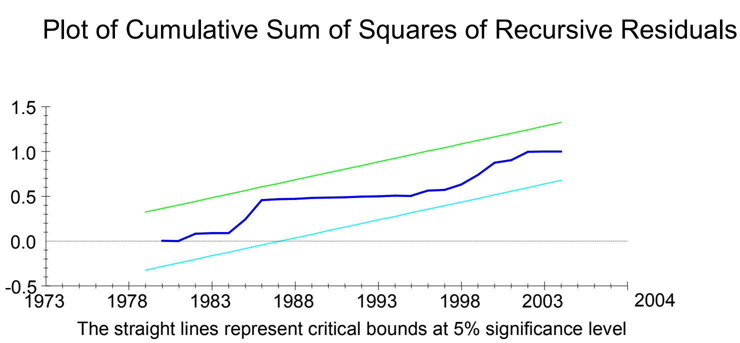


Figure 2: Plot of CUSUM SQUARES Tests for Equation (7)



5. Conclusions and Policy Implication

This paper has used cointegration analysis and the ECM to examine the relationships between investment output ratio, real output and real rate of interest for Bangladesh. Specifically, the study applies the DF_GLS unit root tests to ascertain the time series properties of investment output ratio, real output and real interest rate. The study next applied the Johansen cointegration tests to determine the long run relationships between investment output ratio, real output and real interest rate. The study finally implements the ECM to determine the short run dynamics between investment output ratio, real output and real interest rate.

The results from the DF_GLS unit root tests indicate that the investment output ratio, real output and real interest rate are first difference stationary. The results from the Johansen cointegration tests suggest that the investment output ratio, real output and real interest rate series are cointegrated. This finding indicates that the three time series including investment output ratio, real output and real interest rate have long run equilibrium relationship. To check the robustness of provided by the Johansen tests, the study implemented the Gregory-Hansen residual-based cointegration tests, which allow for structural break in the data. The results from the Gregory-Hansen cointegration tests corroborated those provided by the Johansen procedures; that investment output ratio, real output and real interest rate are cointegrated.

The results from the ECM reveal that real output and interest rate have significant implications for investment. This finding is consistent with the neo-classical investment theory which stipulates that greater output enhances investment, while increases in real interest rate are detrimental to investment. The analysis suggests that policies designed to lower the real interest rate, or, in general, to reduce the real cost of capital, should be favorable for the investment to output ratio of the Bangladesh economy. These might include policies aimed at encouraging savings, or policies targeted at developing and improving financial markets. The monetary authorities can achieve the suggested objectives by lowering the discount rate and the reserve requirements.

Data Appendix

P = GDP deflator. Data are derived from International Financial Statistics (IFS-2005).

Y = Real GDP at factor cost. Data are from (IFS-2005) and ADB Database(2005).

R = Real rate of interest. It is computed as the difference between nominal long term interest rate and GDP deflator inflation rate. Data obtained from (IFS 2005) and the ADB Database (2005).

I = Nominal gross fixed capital formation deflated by GDP deflator. Data are derived from (IFS-2005) and ADB Database (2005).

DUM = Dummy variable. *DUM* is constructed as 1 from 1985 to 1990 and zero in other years. It captures the effects of financial reforms and liberalization for Bangladesh.

Note:
All variables except the rate of interest and *DUM* are converted to natural logs.

Table 1A: Identification and Exogeneity Tests

Bangladesh			
	$\Delta\ln(I/Y)_t$	$\Delta\ln Y_t$	ΔR_t
$ECMI_{t-1}$	-0.529	-0.004	0.101
	(4.27)*	(0.43)	(0.53)
$ECMY_{t-1}$		0.004	
		(0.43)	
$ECMR_{t-1}$			-0.044
			(0.24)

Notes:

1. The absolute *t*- ratios are reported below the coefficients. Significance at 5% is indicated by *.
2. $ECMI_{t-1}$, $ECMY_{t-1}$ and $ECMR_{t-1}$ are the lagged residuals of the cointegrating vectors normalized on investment output ratio, real income and real rate of interest, respectively.

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