Cardiff Economics Working Papers

Working Paper No. E2008/24

Does Public Investment Boost Economic Growth? Evidence from An Open-Economy Macro Model for India

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October 2008

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Work in Progress

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Abstract: Using annual data for India for the period 1984-2003 and employing parametric technique (GMM), the present paper jointly determines GDP growth, real exchange rate and net foreign assets in Indian economy. There is evidence that public investment exerts a significant influence on real exchange rate and the growth rate and does so non-linearly. A comparison of the Indian estimates with those available for the UK and the USA economies is also revealing and highlights the role of governance on the effects of public investment.

Keywords: Public investment; Economic growth; Real exchange rate; Simultaneous model; Generalised method of moments

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1. Introduction

India's economy is currently undergoing significant macroeconomic adjustments. It is thus important to understand how these changes are affecting government spending in general and public investment in particular. Using an open economy macro model, the present paper 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.

There have been numerous studies on the role of government spending on long term growth (e.g., see Aschauer 1989, Barro 1990, Tazi and Zee 1997). These studies found conflicting results about effect of government spending on economic growth. Barro was among the first to formally endogenize government spending in a growth model and to analyze the relationship between the size of the government and the rate of growth and saving. He concluded that an increase in resources devoted to non-productive (but possibly utility enhancing) government services is associated with lower per capita growth. Tazi and Zee also found no relationship between government size and economic growth. On the other hand Aschauer's empirical results indicate that non-military public capital stock is substantially more important in determining productivity than is the flow of military spending, that military capital bears little relation to productivity and that the basic stock of infrastructure of street, highways, airports, mass transit and water systems has almost explanatory power for productivity. Many studies also attempted to link

government spending to agricultural growth and poverty reduction (Elias 1985, Fan, Hazell and Thorat 2000; Fan, Zhang and Zhang 2000 and Fan and Pardey 1998). Most of these studies found that government spending contributed to agricultural production growth and poverty reduction.

The relationship among fiscal policy, the balance of payments and terms of trade has been investigated in optimizing models since the seminal contributions of Frenkel and Razin (1986a, 1986b, 1992). For instance in Frenkel and Razin(1986a), a lump sum tax cut raises the relative price of non-tradeable good (in addition to the world rate of interest) and this raises (lowers) wealth and consumption for domestic (foreign) economy. Some other important papers that have studied similar issues in a theoretical context are Buiter(1987), Devereux (1987), Giovannini (1988), Turnovsky and Sen (1991) and Ghosh (1992) and Ahmed (1986, 1987), Abell(1990) and Koray and Chan (1991) in an empirical context. Some of the studies on the effect of fiscal variables on real exchange rate use linear techniques to examine whether the effect of fiscal variables is significant. Abell (1990) uses a VAR model for the period 1979-85 for the US to find support for the notion that higher budget deficit, by raising the domestic interest rate, attracting foreign capital and appreciating the home currency, also increase the trade deficit. Non-linear techniques have also been considered in the literature. Simultaneous non-linear equations are applied in Ahmed (1986) where an open economy reacts differentially to temporary and permanent government spending changes. The hypothesis that temporary government spending changes have a significant impact on the balance of trade deficit of an order of magnitude between zero and one is consistently supported by the empirical results.

We try to integrate different strands of the literature and focus on the effects of public investment not only on economic growth, but also on net foreign assets and real exchange rate in a simultaneous equation set-up. While most papers study the effects of fiscal policy either on economic growth or on terms of trade, an important exception in the literature is the Ghosh et al. (2003) study for the US and the UK. The paper develops a two country endogenous growth model with optimizing agents where public investment affects both real exchange rates and long-term growth in a non-linear fashion

While we closely follow the theoretical model of the paper, we study the case of India. Given the recent developments in India's emerging economy, it is rather interesting to study the effects of public investment in India. One particular reason for our interest is the contrast between India on the one hand and the US or UK on the other. In contrast to the US or the UK, India is an emerging economy with much weaker institutional framework. This is evident in a range of institutional features in these countries, especially those related to corruption and national governance (obtained from International Country Risk Guide, published by PRS Group). The Appendix Table A1 summarises the trends in these institutional features for the US, UK and India. Clearly corruption is a serious problem especially when it comes to analyse the effects of public investment (e.g. see Swaroop and Rajkumar, 2002); thus a comparison of India to the US and the UK could highlight the effects of institutions, especially corruption and bureaucracy, on long-run growth and real exchange rate. It is thus interesting to analyse the effects of public investment on India's economic performance in a globalised world, thus justifying the use of an open economy growth model (Ghosh et al. 2003). In particular, we estimate a simultaneous equation model determining economic growth,

real exchange rate and net foreign assets as functions of public investment. In doing so, we also allow for possible non-linearity in the relationship, if any. Results from our sample highlight the significant effect of public investment on GDP, among others; we also detect non-linear nature of the relationship in this respect.

The paper is developed as follows. Section 2 outlines the theoretical model. Section 3 discusses the data and methodology while section 4 analyses the results and the final section concludes.

2. Analytical Arguments

2.1 The Basic Model

We follow the model by Ghosh et al. (2003) which is a two-good, two-country model with perfect capital mobility where long-run growth is driven by productive public investment in one of the countries. The home (foreign) country is called country a (b). To keep the analysis simple we assume that each country produces one good but consumes both goods. Fiscal policy will have an effect on terms of trade in such framework. In country a (b) household-producers produce good 1 (good 2) which is called the home (foreign) good. In addition to using their own capital stock (K_a), they have spillover (or knowledge) effects from the capital stock of the foreign country (K_b) and also from the economy wide public investment in country a (G_a). Labour is assumed to be inelastically supplied and is normalized to 1. Here we present the basic structure of the model

The production function for country a can be written as follows

$$Y_A = A_1 K_a^{\gamma_1} G_a^{\gamma_2} K_b^{1-\gamma_1-\gamma_2} \quad , A_1 \ \phi \ 0{,}0 \ \pi \ \gamma_1, \gamma_2 \ \pi \ 1 \ldots\ldots\text{(1a)}$$

The production function of country b is given by

$Y_b = A_2 K_b^{\gamma_1} G_b^{\gamma_2} K_a^{1-\gamma_1-\gamma_2}$, A_2 ϕ 0 …….(1b)

The representative consumer in country a maximizes a logarithmic utility function which is given by

$$U_a = \int_0^\infty \ln\left(C_{1a}^{\alpha} C_{2a}^{1-\alpha}\right) e^{-\rho t} dt \text{ ……(2a)}$$

where C_{1a} is consumption home good (good 1) and C_{2a} is consumption of foreign good (good 2) .

The dynamic wealth constraint is expressed in terms of domestic good as

$$W_a = K_a + B_a + F_a = (1-\tau_a)(y_a + r_a B_a + r_a F_a) - C_a \text{ ……..(3a)}$$

where $F_a = \prod F, C_a = C_{1a} + \prod C_{2a}$

where W_a is asset wealth which comprises physical capital, K_a, domestic bond ,B_a and foreign assets (expressed in terms of domestic good), F_a. τ_a is flat rate income tax and r_a is domestic real interest rate. C_a is total consumption of both goods in terms of the home good. $\prod$ is the real exchange rate(RER), defined as the price of good 2 in terms of good 1.

The optimization exercise for the individual in country a yields the condition

$$\varepsilon_a \equiv \frac{C_{1a}}{C_{1a}} = (1-\tau_a) r_a - \rho \text{ ……..(4a)}$$

The first order condition in country b yields

$$\varepsilon_b \equiv \frac{C_{1b}}{C_{1b}} = (1-\tau_b)r_b - \rho \text{ .....(4b)}$$

The dynamic government budget constraint for country a is given by

$$B_a = r_a B_a + G_a - \tau_a (Y_a + r_a B_a + r_a \prod F) \text{.....(5a)}$$

For country b the dynamic government budget constraint is

$$B_b = r_b B_b + G_b - \tau_b (y_b + r_b B_b - r_b F) \text{.....(5b)}$$

The three equilibrium conditions for the world economy- the two goods market equilibrium conditions for country a and b and the balance of payment equilibrium are given by (6a), (6b) and 7

$$K_a = Y_a - G_a - C_{1a} - C_{1b} \text{.....(6a)}$$

$$K_b = Y_b - G_b - C_{2a} - C_{2b} \text{.....(6b)}$$

$$(\prod F) = (C_{1b} - \prod C_{2a}) + r_b (\prod F) \text{.....(7)}$$

Here C_{ij} (i = 1, 2, j = a,b) denotes aggregate consumption of the ith good by residents in the jth country.

Capital is perfectly mobile across countries, which means that the uncovered interest rate parity condition holds at any point of time.

This is given by $r_a = r_b + \prod$ .....(8)

These are the key equations of the model.

The per output variables are defined as follows

$$k_a \equiv \frac{K_a}{Y_a}, g_a \equiv \frac{G_a}{Y_a}, c_{1a} \equiv \frac{C_{1a}}{Y_a}, c_{2a} \equiv \frac{C_{2a}}{Y_b}, f = \frac{F}{Y_b}, \pi = \prod Y_b / Y_a$$

2.2 Hypotheses

a) Growth rate

The growth rate responds to public investment g_a in a non-linear fashion. This is because, for relatively small rises in g_a, the positive effect on growth rate dominates, but beyond a critical value of g_a, the negative effect (on national saving) outweighs the positive effect (on marginal productivity of capital) and growth rate falls with g_a. Therefore from the empirical exercise we could expect non-linearities in the behaviour of the growth rate when we study its movement against g_a.

b) Real exchange rate

RER initially falls that is imported good becomes relatively cheaper as g_a rises, but as g_a is raised beyond a certain level , there is a rise in RER. The initial fall in RER is due to an improving trade balance arising out of a rise in c_{1b} together with a fall in c_{2a}, while the subsequent rise in RER is attributable to the fact that ultimately c_{1a} falls as well as c_{2a} as private consumption is increasingly crowded out by tax-financed public investment.

c) Balance of payments and net foreign assets

At the initial RER, there should be a trade surplus given in per output terms. Consequently the terms of trade should initially improve (i.e. π should decrease). This situation is reversed after a point, as consumption of the home good falls- a consequence of private consumption being increasingly crowded out by public investment. In

transiting from one steady state to another, the trade surplus (deficit) must be sufficient to finance $r\pi f$, which represents interest payments on the net foreign assets accumulated (decumulated)

3. Data Description

All relevant data have been obtained from the International Financial Statistics. We choose the period 1984-2003 for the analysis in this paper, after the introduction of the flexible exchange rate regime. This allows us to consider the Indian economic transition over last few decades.

The primary variable of our interest is the real exchange rate (RER) which is defined as the ratio of unit value of imports to unit value of exports, the long run growth rate (GDPGR). Government investment and net foreign assets are expressed as a proportion of GDP and are denoted by GINVGDP and NFAGDP respectively. Following our theoretical model we have three endogenous variables- RER, GDPGR, NFAGDP. Government investment as a proportion of GDP (GINVGDP) is the only exogenous variable. We use the data on gross fixed capital formation as government investment data.

3.1. Indian economic transition

Table 2A shows the means and standard deviations of all four variables, namely, public investment, GDP growth rate, real exchange rate and net foreign assets over the sample period for India. We also split the sample period into two sub-periods: 1984-1993, 1994-2003; the latter highlights the fluctuations in the average values of these variables over

the sub-periods, as economic policy changed from more inward looking into more outward looking approach 1983-1992 until the formal economic liberalization was launched in 1991-92.

Figure 1e shows the time series plots of public investment and GDP growth rate over the sample period for India.

3.2. Unit Root Tests

Before determining the variables of interest, one needs to test for the stationarity of the variables. We perform both augmented Dickey Fuller (ADF) and Phillips Perron (PP) unit root tests for all the variables GDPGR, RER, NFAGDP, GINVGDP; we also examine the stationarity of the quadratic and cubic terms of GINVGDP. The results of the unit root tests are given in Table 3 and Table 4 for the two sets of tests respectively. The ADF test and PP test suggest that GDPGR is stationary and RER, GINVGDP and the quadratic and cubic terms of GINVGDP are stationary at levels.

3.2 Non-linearity in the data

Next we examine the scatter plot with kernel fit between GINVGDP on the one hand and measures of economic growth, real exchange rate and net foreign assets on the other. These are shown respectively in Figures 2-4. All three scatter diagrams highlight the non-linear relationship between each pair of variables i) GDPGR and GINVGDP (Figure 2), and ii) NFAGDP and GINVGDP**.** (Figure 3) iii) RER and GINVGDP (Figure 4)

4. Model Specification and Results

4.1. Model specification

While the theoretical model suggests that the endogenous variables GDPGR, RER, NFAGDP are simultaneously determined for a given value of the exogenous variable GINVGDP, the scatter diagram with Kernel fit suggests that there is a non-linear bivariate relationship between a) GDPGR and GINVGDP, b) GINVGDP and RER, c) GINVGDP and NFAGDP. We thus proceed to determine the following three equations system:

$$GDPGR=c1+c2.GINVGDP+c3.GINVGDP^2+C4.GINVGDP^3 +c5.RER+c6.NFAGDP+u1 \quad (9)$$

$$RER=c7+c8.GINVGDP+c9.GINVGDP^2+C10.GINVGDP^3 +c11.GDPGR+c12.NFAGDP+u2 \quad (10)$$

$$NFAGDP=c13+c14.GINVGDP+c15.GINVGDP^2+C16.GINVGDP^3 +c17.GDPGR+c18.RER+u3 \quad (11)$$

We use generalized methods of moments for estimation. The advantage of GMM is that it has a general functional form (that also incorporates non-linearity in variables or parameters) and also allows for non-zero correlation between the error term and the right hand side variables. It also provides corrections for heteroscedasticity and autocorrelation. Accordingly we choose the GMM technique for our empirical analysis..

In vector matrix notation the above system is written as follows:

$$Y_t=h(X_t,\beta) +u_t$$

Where $E(u)=0$ and $E(uu')=\sum$ Here β is a k*1 parameter that we wish to estimate where $cov(u_t, h(X_t, \beta) \neq 0$, $cov(u_t,X_j) \neq 0$ for all $i \neq j$. Here Y is the vector of dependent variables

and X is the matrix of explanatory variables. The general form of the function $h(X_t,\beta)$ allows for possible non-linearity. The theoretical relation that the parameters should satisfy are usually the orthogonality conditions between $h(X_t,\beta)$ and a set of instrumental variables , say, $\{z_t\}$

$$E[h(.)'Z]=0$$

Lagged values of RER, GDPGR and NFAGDP are used as instruments of RER, GDPGR and NFAGDP respectively.

4.2. Results

The GMM estimates of equations 9-11 are given in Table 5. Considering 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 RER is positive (when GDPGR is the dependent variable in GMM estimation)

In this respect it is also interesting to compare our results with Ghosh et al (2003). We do not find the same signs of the coefficients of public investment and its squared term and cubic terms as found by Ghosh et al (2003) for the UK economy. In case of India the sign of the coefficient of GINVGDP is positive, the coefficient of the quadratic term is negative and the coefficient of the cubic term is positive(like the case of US economy found by Ghosh et al (2003)).. In case of UK the sign of the coefficient of GINVGDP is negative, the coefficient of the quadratic term is positive and the coefficient of the cubic term is negative. In case of India the negative sign of the squared term of

public investment (where GDPGR is the dependent variable) indicates the leakage in the system due to corruption.

5. Conclusion

Using annual data for India for the period 1984-2003 and employing parametric technique (GMM), the present paper jointly determines GDP growth, real exchange rate and net foreign assets in Indian economy. There is evidence that public investment exerts a significant influence on real exchange rate and the growth rate and does so non-linearly. A comparison of the Indian estimates with those available for the US and the UK economies is also revealing and highlights the role of governance on the effects of public investment.

Table 1. List of Variables

GDPGR	Rate of growth of gross domestic product
RER	: Ratio of unit value of imports to unit value of exports
NFAGDP	Net foreign asset as a proportion of GDP
GINVGDP	Government investment as a proportion of GDP
$GINVGDP^2$	Square of GINVGDP
$GINVGDP^3$	Cube of GINVGDP

Table 2A. Descriptive statistics for Indian data

	Mean	Standard deviation
Public investment		
1984-2003	0.219991	0.009712
1984-1993	0.216086	0.010228
1994-2003	0.223897	0.007785
Economic growth rate		
1984-2003	0.120902	0.30603
1984-1993	0.133912	0.027348
1994-2003	0.107891	0.029206
Real exchange rate		
1984-2003	1.047854	0.150166
1984-1993	1.156019	0.112411
1994-2003	0.939689	0.094708
Net foreign assets		
1984-2003	0.050643	0.046435
1984-1993	0.013434	0.006163
1994-2003	0.087852	0.037912

Table 2B: Descriptive Statistics for UK data (1972-1997)

Variables	Mean	Standard Deviation
Growth	0.02	0.02
GINVGDP	0.07	0.03
RER	1.01	0.06

Table 2C:Descriptive Statistics for US data (1972-1997)

Variables	Mean	Standard Deviation
Growth	0.018	0.01
GINVGDP	0.03	0.002
RER	0.97	0.09

Table 3. Unit Root Test For Indian data (ADF test)

	ADF statistic	5% Critical value	10% critical value
GDPGR	-2.671842**	-3.020686	-2.650413
RER	-4.315931*	-3.020686	-2.650413
NFAGDP	3.765230	-3.020686	-2.650413
GINVGDP	-2.856302**	-3.020686	-2.650413
$GINVGDP^2$	-2.811226**	-3.020686	-2.650413
$GINVGDP^3$	-2.777756**	-3.020686	-2.650413

*denotes rejection of null hypothesis of unit root at 5% significance level and ** denotes rejection of the null of unit root at 10% significance level.

Table 4. Unit Root test For Indian data (Phillips Perron test)

	P-P statistic	5% Critical value	10% critical value
GDPGR	-2.777812**	-3.020686	-2.650413
RER	-3.370714*	-3.020686	-2.650413
NFAGDP	4.148046*	-3.020686	-2.650413
GINVGDP	-3.438564*	-3.020686	-2.650413
$GINVGDP^2$	-3.093173*	-3.020686	-2.650413
$GINVGDP^3$	-2.961542**	-3.020686	-2.650413

*denotes rejection of null hypothesis of unit root at 5% significance level and ** denotes rejection of the null of unit root at 10% significance level.

Table 5. Results obtained from Generalised Methods of Moments for Indian Data (1984-2003)

	Coefficient	T-statistic
Dependent variable GDPGR		
Intercept	0.5678	0.916549
GINVGDP	13.42944	2.102366*
$GINVGDP^2$	-25.7601	-2.072262*
$GINVGDP^3$	31.9793	2.071947*
RER	0.121059	1.045820*
NFAGDP	0.375815	1.688945*
R squared	0.615756	
S.E. of regression	0.045688	
J stat	2.20E-26	

Dependent variable: RER		
	Coefficients	T-stat
Intercept	0.23459	1.364057
GINVGDP	10.9328	1.907064*
$GINVGDP^2$	-32.8310	-1.886218*
$GINVGDP^3$	26.2344	1.869073*
GDPGR	2.260418	1.045820
NFAGDP	-3.104386	-0.742428
R^2	0.515614	
J stat	2.77E-26	
S.E. of regression	0.037741	

Dependent variable: NFAGDP		
	Coefficients	T-stat
Intercept	0.011563	0.076381
GINVGDP	35.73421	1.146567*
$GINVGDP^2$	-46.213666	-1.151277
$GINVGDP^3$	64.566731	1.158809
GDPGR	2.660886	1.688945*
RER	-0.322125	-0.742428
R^2	0.123451	
J stat	1.33E-21	
S.E. of regression	0.121570	

* denotes that the variable is significant at 10% level or lower.

Figure 1a

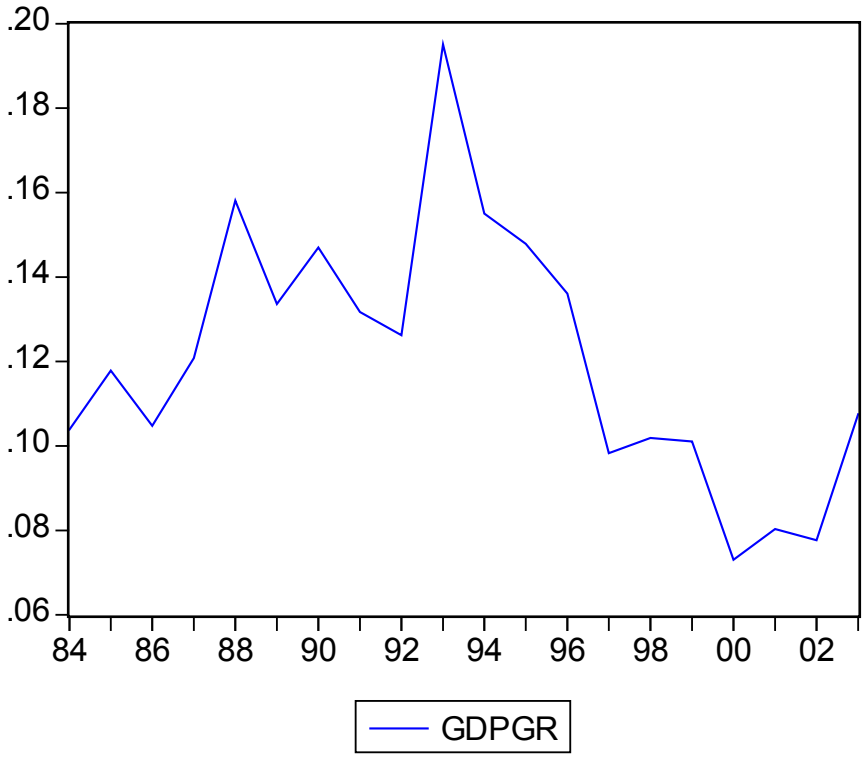

Figure 1b

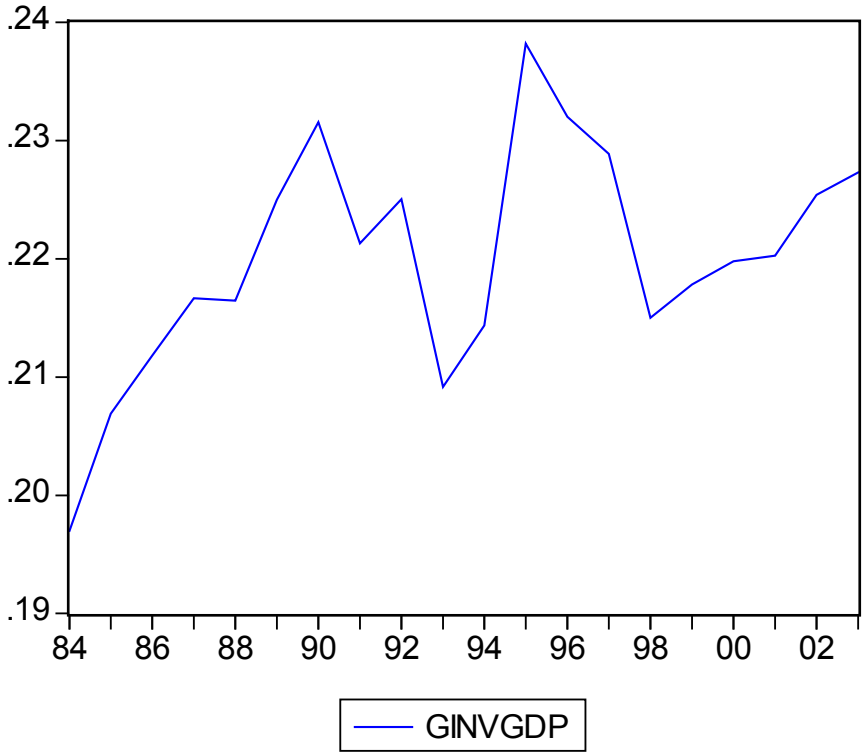
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Figure 1c

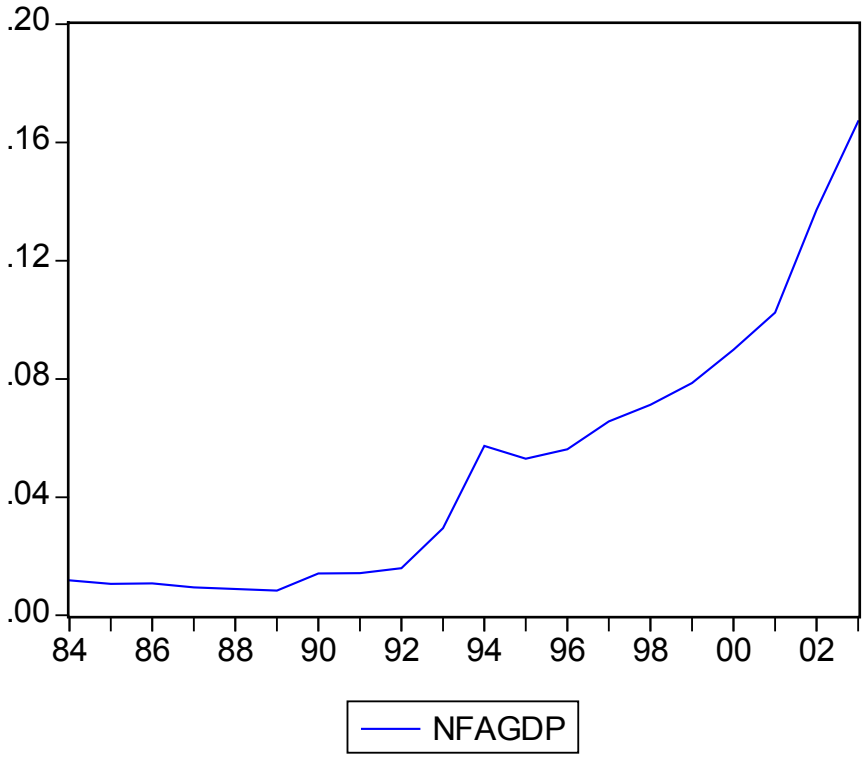
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Figure 1d

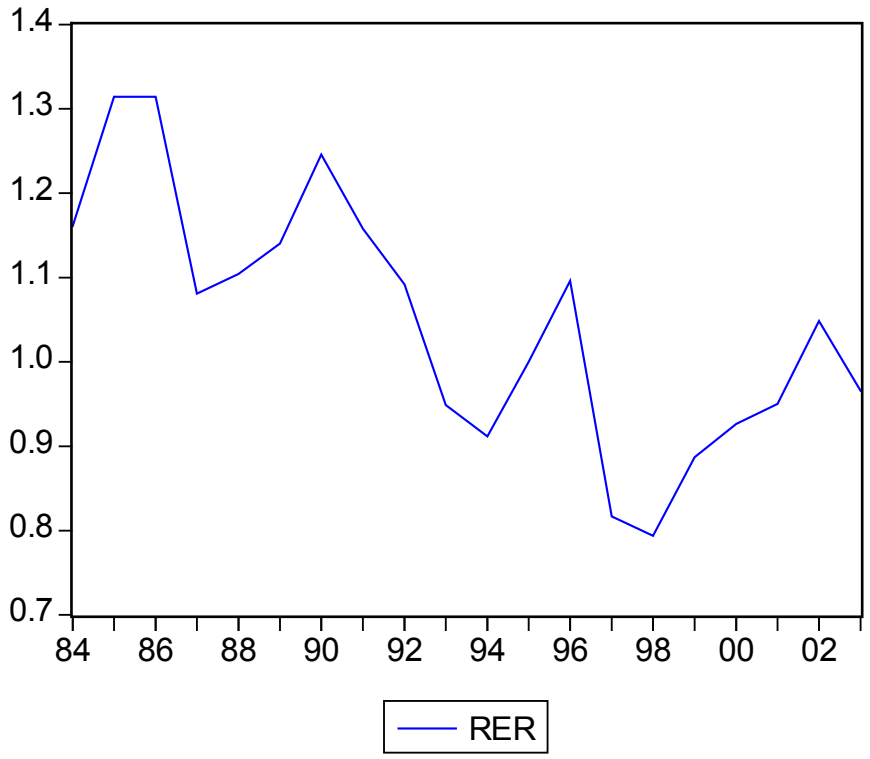


Figure 1e

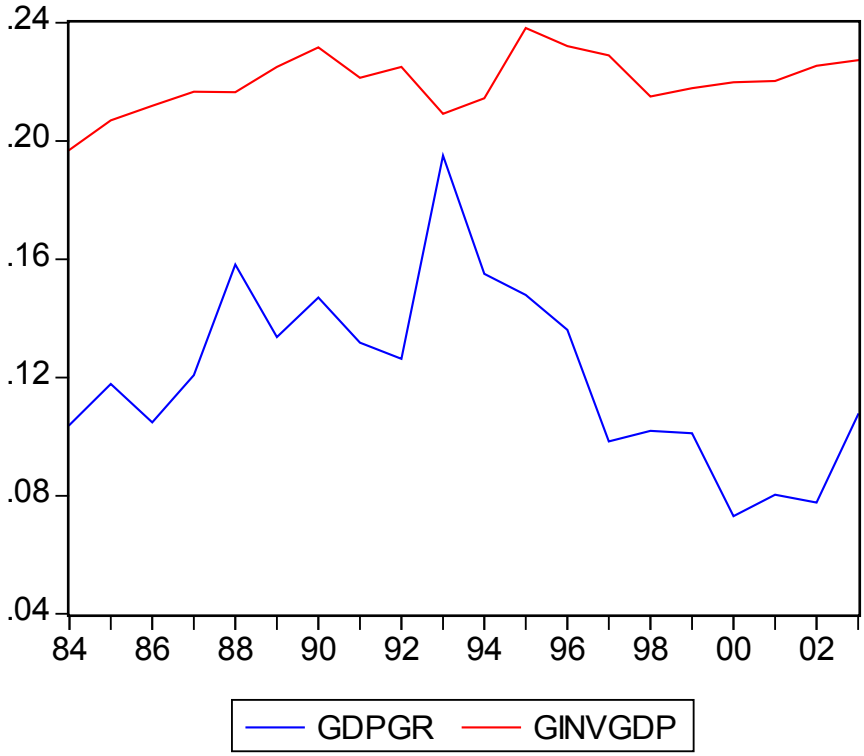


Figure 2. Relationship between public investment and GDP growth rate

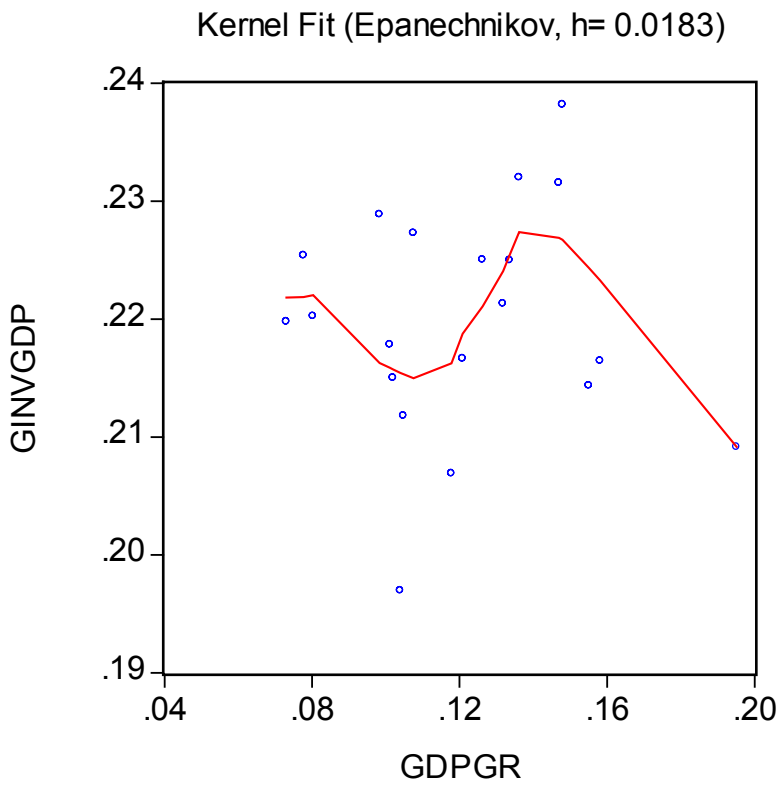


Figure3: Relationship between public investment and net foreign asset

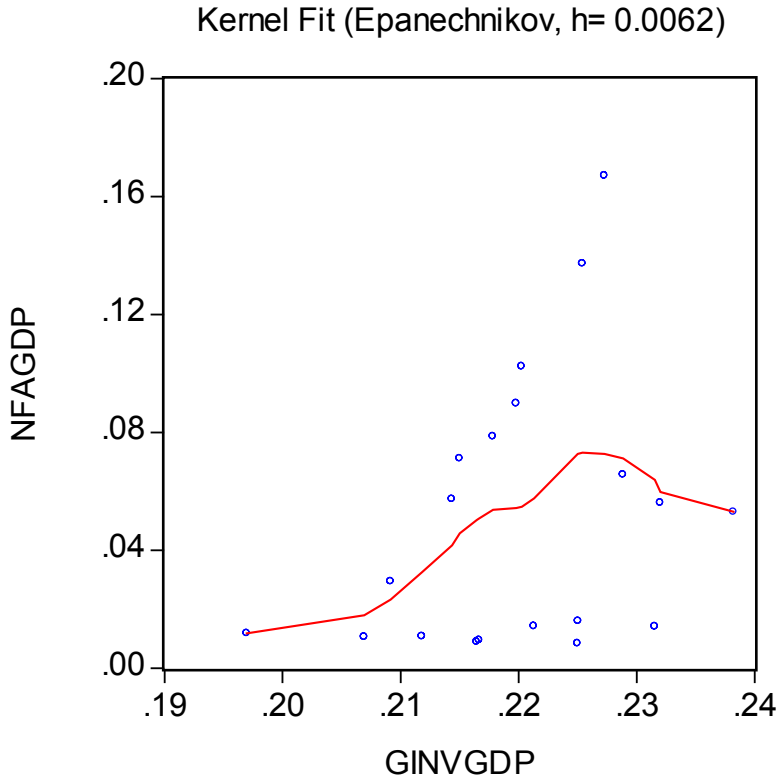
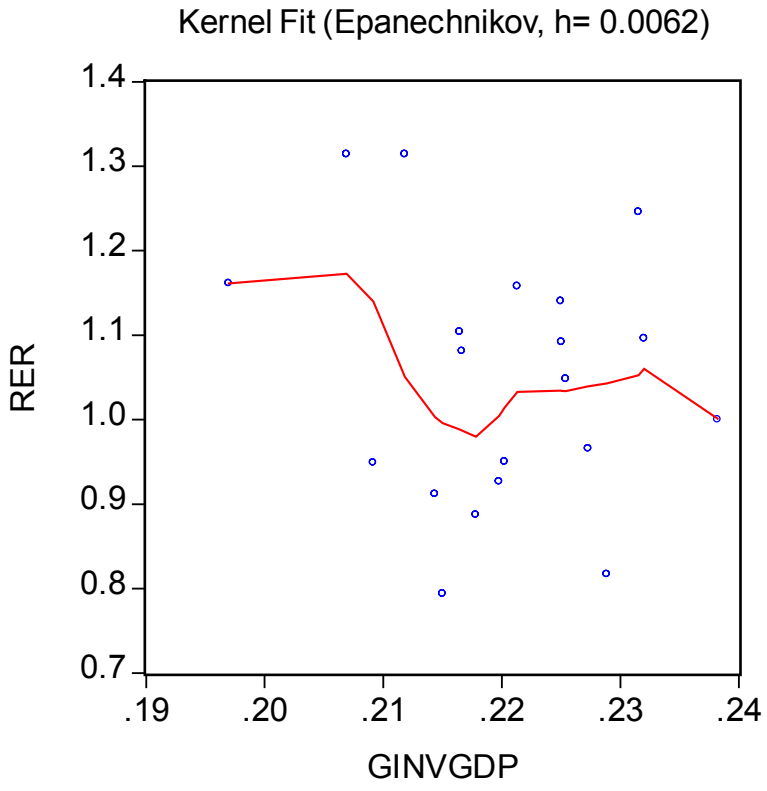


Figure 4. Relationship between public investment and real exchange rate



Appendix

Table A1. A comparison of institutional environment in the 1990s – India, US & UK

Year	US	UK	India
Corruption index	>=5	>=5	<=3
Bureaucratic control index	4	4	3
Rule of the law index	6	6	3-4

Data Source: International Country Risk Guide Published by the PRS Group

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