Fiscal Deficit, Capital Formation, and Crowding Out : Evidence From India

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Abstract

Theoretical literature identifies two variants of crowding out in an economy–real and financial. The *real (direct) crowding out* occurs when the increase in public investment displaces private capital formation broadly on a *dollar-for-dollar* basis, irrespective of the mode of financing the fiscal deficit. The *financial crowding out* is the phenomenon of partial loss of private capital formation, due to the increase in the interest rates emanating from the pre-emption of real and financial resources by the government through bond-financing of fiscal deficit. The paper analysed the real and financial crowding out in India during 1970-71 to 2002-03. Using asymmetric vector autoregressive model, the paper finds no real crowding out between public (in particular, infrastructure) and private investment; rather complementarity is observed between the two. The dynamics of financial crowding out is captured through the dual transmission mechanism *via* real rate of interest; that is, whether private capital formation is interest rate sensitive and in turn whether the rise in real rate of interest is induced by fiscal deficit. The study found empirical

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evidence for the former, but not the latter, reinforcing no financial crowding out in India.

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Theoretical literature identifies two variants of crowding out in an economy–real and financial. The *real* (direct) crowding out occurs when the increase in public investment displaces private capital formation broadly on a *dollar-for-dollar* basis, irrespective of the mode of financing the fiscal deficit (Blinder and Solow, 1973). The *financial crowding out* is the phenomenon of partial loss of private capital formation, due to the increase in the interest rates emanating from the pre-emption of real and financial resources by the government through bond-financing of fiscal deficit.[1] In recent years, in the context of macroeconomic management in India, it has often been argued that high fiscal deficit is affecting capital formation in the economy both by reducing private investment through an increase in interest rate and also through reduction in public sector's own investment arising out of ever-increasing consumption expenditure.[2]

Many authors have empirically tested the real (direct) crowding out and found contradictory results. Ramirez (1994), Greene and Villanueva (1990), Buiter (1977), Aschauer (1989), and Erenburg (1993) found that public investment and private investment have a complimentary relationship; while Blejer and Khan (1984), Cebula (1978), Shafik (1992), Parker (1995), Ostrosky (1979), Tun Wai and Chong (1982), Sunderrajan and Takur (1980), Pradhan, *et.al.* (1990), Krishnamurty (1985), Kulkarni and Balders (1998), and Alsenia (2002) did find evidence for crowding out between public and private investment (*Appendix 1*). The common analogy for former set of studies is that increase in public capital formation stimulate aggregate demand and in turn increases private investment. Another link for the existence of this complimentary relationship is that a higher stock of public capital, in particular infrastructure, may increase the return of private investment projects. The latter set of studies on crowding out argued that public investment might act as a substitute for private investment. This substitutability can arise when private sector utilises the public capital for its required purposes rather than expand private capacity.[3]

The general criticism about these studies on crowding out is that it failed to look into the aspects of the *financial crowding out*. Contrary to real (direct) crowding out, empirical investigation of the financial crowding out is not straightforward and simple. The financial crowding out can be empirically established through a dual mechanism *via* rate of interest; firstly, whether private investment is interest rate sensitive and secondly, whether rate of interest is induced by fiscal deficit. This two-fold analysis is significant because even if private investment is interest rate sensitive, this aspect by itself does not mean occurrence of financial crowding out if rate of interest is not deficit induced.[4]

Apart from this, many of these studies confined the analysis of real (direct) crowding out to aggregate level of public investment, neglecting whether the infrastructure and non-infrastructure mix of public capital formation has differential impacts on private capital formation. Also, most of these studies suffer from acute methodological deficiencies as they assumed the respective timeseries as stationary and proceeded the analysis by applying ordinary least squares. In other words, earlier studies have failed to address that time series may contain unit root and be non-stationary at levels, which can lead to spurious regression results, which would yield inconsistent estimates.

This paper examines the real (direct) and financial crowding out in the context of India over the last four decades. This study is different from the existing studies on crowding out in India for four reasons. Firstly, the study bridged the lacuna of *partial analysis status* of financial crowding out in India by analysing not only whether private investment is interest rate sensitive, but also to whether the rise in interest rate is deficit-induced. Secondly, after correcting for unit roots and co-integration, the problems of simultaneity and *adhoc* specification of lag structure are also eliminated in this paper by applying Hsiao's asymmetric vector autoregressive framework. Thirdly, the aspects related to non-homogeneity of public investment are captured through separate model specifications incorporating public infrastructure investment and non-infrastructure investment. Fourthly, as interest rate was administered till recently in India, whether the administered rate of interest reflects the market signals became the pertinent question that thwarted any attempt on financial crowding out in the context of India. This problem is tackled in this paper by decomposing the rate of interest series to understand the inflationary expectations intrinsic in it and tried to analyse whether the real rate of interest shows a varying trend along with the inflationary expectations in the intertemporal scale. The point to be noted here is

that though the nominal rate of interest showed a non-varying trend particularly during the administered interest rate regime in India, it may not be so when it comes to the real rate of interest series. Real rate of interest showed substantial volatility intertemporally. This in turn validates that rate of interest, though administered, reflect market signals.

The paper has been divided into five sections. Apart from the introduction, section 2 discusses the analytical framework of the study. Section 3 interprets the data and section 4 discusses the econometric results. Section 5 summarises major findings of the paper and draws conclusions.

II. Analytical Framework for Crowding Out

Though the neoclassical-flexible accelerator model has been the most widely accepted general theory of investment behaviour, the application of these models in the context of developing countries posed certain challenges owing to the key assumptions of the models such as perfect capital markets and little or no government investment (Greene and Villanueva, 1991). With the relatively significant role of government in capital formation in developing countries, the standard models of investment could not be directly adapted to developing countries. Furthermore, even if standard models could be directly adapted to developing countries, severe data constraints arise when attempts are made to implement them empirically (Blejer and Khan, 1984).[5] Given these constraints, the paper attempts to develop a model for private investment in the context of India in line with the existing attempts on modeling private investment in the context of developing countries primarily using neo-classical-flexible accelerator models.[6]

Theoretically, gross investment in private sector is defined equal to net investment in private sector plus depreciation of the previous capital stock. While net investment in private sector is defined as the difference between the desired stock of capital in period *t* and the actual stock in the previous period *t-1*.

$$I_{pvt} = \Delta KP_t + dKP_{t-1} \qquad (1)$$

where I_{pvt} = Gross Private Investment
$DKP_t = N_{pvt}$ = Net Private Investment

d = rate of depreciation

$$N_{pvt} = \Delta KP_t = b\,(KP_t^* - KP_{t-1}) \tag{2}$$

where KP_t^* = desired stock of capital in private sector

KP_{t-1} = actual stock of capital in private sector in the previous period.

β = coefficient of adjustment, $0 \leq \beta \leq 1$

Substituting equation (2) in (1), we get:

$$I_{pvt} = b\,(KP_t^* - KP_{t-1}) + dKP_{t-1} \tag{3}$$

In the standard lag-operator notation, equation (3) can be rewritten as:

$$I_{pvt} = [1-(1-d)L]KP_t \tag{4}$$

where L is the lag operator, $LKP_t=KP_{t-1}$.

Now, we specify a partial adjustment function for gross investment, as follows:

$$\Delta I_{pvt(t)} = b\,(I^*_{pvt(t)} - I_{pvt(t-1)}) \tag{5}$$

where $I^*_{pvt(t)}$ is the desired level of private investment. In the steady state, desired private investment is given by:[7]

$$I^*_{pvt} = [1-(1-d)L]KP_t^* \tag{6}$$

Combining the equations (5) and (6), and solving for $I_{pvt(t)}$ yields the equation as follows:

$$I_{pvt(t)} = b[1-(1-d)L]KP_t^* + (1-b)I_{pvt(t-1)} \tag{7}$$

We know that in the accelerator models, desired stock of capital can be assumed to be proportional to the output expectations in the economy.

$$KP_t^* = aY_t^* \tag{8}$$

where Y_t^* is the expected output in the economy.[8]

Substituting equation (8) in equation (7), we get:

$$I_{pvt(t)} = ba[1-(1-d)L]Y_t^* + (1-b)I_{pvt(t-1)} \quad (9)$$

The *beta coefficient* in the equation, which captures the response of private investment to the gap between desired and actual investment, which in turn is assumed to vary systematically with the economic factors that influence the ability of private investors to achieve the desired level of investment. The paper hypothesises that the response of private investment depends on the availability of financing (cost and quantity of credit, *viz*., i_r and C_{pvt}) and the level of public sector investment (I_{pub}).[9]

$$b = f\{C_{pvt}, i_r, I_{pub}) \quad (10)$$

A linear regression model for private investment can thus be constructed assuming equations (9) and (10) are linear.

$$I_{pvt} = a + b_1 I_{pvt(-1)} + b_2 I_{pub} + b_3 i_r + b_4 C_{pvt} + b_5 Y^* + n_t \quad (11)$$

Before econometrically estimating the equation (11), next section interprets the data in the context of India related to these macrovariables.

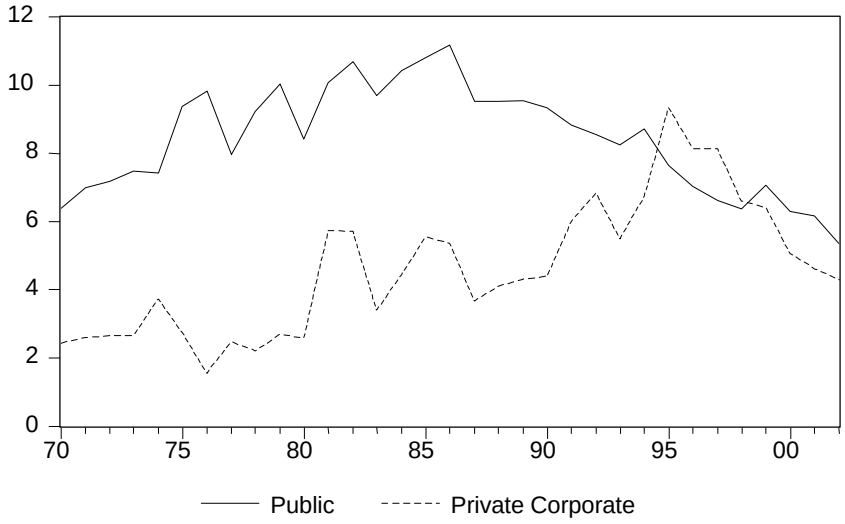
III. Interpreting Data

Data on capital formation in public and private sectors is drawn from the new series of National Account Statistics published by Central Statistical Organisation. Data on other macrovariables of study *viz*. rate of interest, rate of inflation, the availability of credit to private sector, gross domestic product, gross fiscal deficit, exchange rate and money supply are drawn from various issues of *Handbook of Statistics on Indian Economy*, published by Reserve Bank of India. The period of analysis is between 1970-71 to 2002-03.

In the context of India, for the estimation of capital formation, the economy is divided into three broad institutional sectors, *viz.*, public sector, private corporate sector and household sector. The household sector is conceived as the 'residual' sector embracing all economic entities other than the units of public and private corporate

sector essentially as clubbing together the left-over or the unknown of all units[10]. In the light of these data problems, it should be noted that the household investment data is not entirely reliable and kept outside the purview of private investment in this paper. The gross capital formation noted a declining trend in the public sector especially in the late 1990s while private corporate sector investment has shown an increase (*Figure 1*).

Figure 1: Trends in Public Investment and Private Corporate Investment as percent of GDP

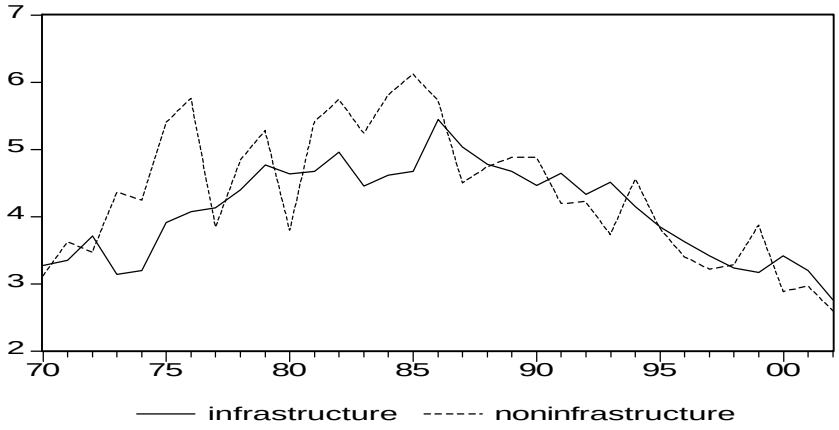


The public sector played a significant role in the investment process in the 1970s, which is around the peak of around 10 percent of GDP; and then in the mid-80s it further grew to around 12 percent of GDP, before it decline to 6 percent of GDP in late-90s. The private corporate sector which was only 2.44 percent of GDP in 1970-71 has gained momentum in the 1980s and reached around 6 percent of GDP in the mid-80s when the public investment was as high as 12 percent of GDP. The private corporate investment crossed over the public investment in terms of GDP in early 1990s and reached a peak of 9.57 percent of GDP in 1995-96 despite a marginal declining trend thereafter. The trends related to the dominance of public sector were partially reversed after the burgeoning fiscal crisis of 1990s, which led to a retrenchment in public investment with a simultaneous expansion of private capital accumulation, emanating from the booming private corporate investment in the decade of industrial delicensing and trade liberalisation.

3.1 Non-homogeneity of Public Investment

The public capital formation in India is of non-homogeneous in nature and can broadly divided into infrastructure and non-infrastructure investment. Following Parker (1995), public infrastructure investment is defined as the aggregate of capital formation in agriculture, electricity, water supply, oil and transport and communication. While the public non-infrastructure is defined as capital formation in manufacturing, mining and quarrying, trade, hotels and restaurant, finance, and insurance etc.

Figure 2: Trends in Infrastructure and Non-infrastructure Investment-GDP Ratio

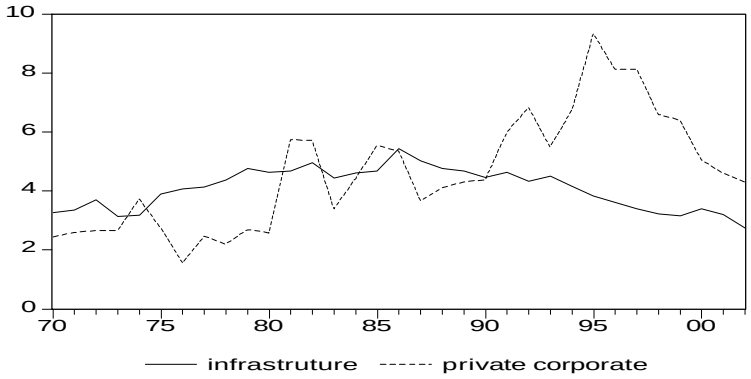


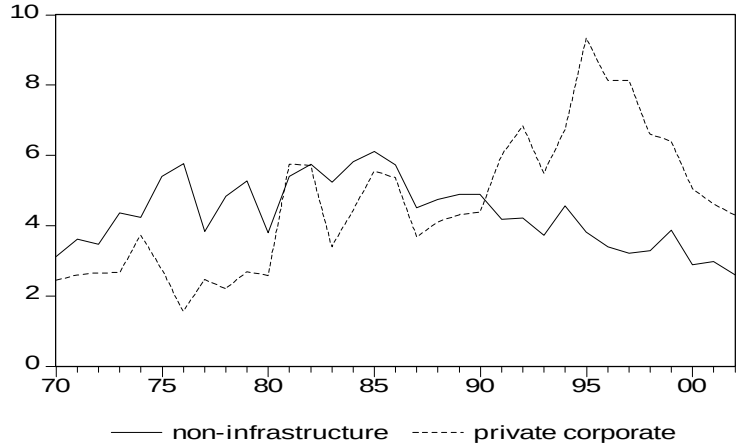
Based on this classification, it is noted that the gap between both series widened in mid eighties; however, both series showed a declining trend during the nineties (*Figure 2*). It is interesting to note that the decline in public capital formation is more in case of non-infrastructure investment than infrastructure investment since eighties.

In terms of crowding out, public investment – both infrastructure and non-infrastructure investment – is the most significant determinant of private capital formation. It is important to analyse whether different types of public investment likely to have conflictive or mutually reinforcing effects on private capital formation; public investment in infrastructure *prima facie* tend to attract private investment while public investment in non-infrastructural activities where public enterprises do what private firms too can do might have substitution effects. The comovements of public infrastructure and

non-infrastructure investment with private corporate investment are given in *Figure 3.*

Figure 3: Co-movements of Public Infrastructure and Non-infrastructure Investment with Private Corporate Investment (as percent of GDP)





Public infrastructure investment, which was 3.2 percent of GDP in 1970-71 had increased to 5.44 percent in 1986-87 and thereafter had noted a steady decline to 2.76 percent of GDP in 2002-03. Private corporate investment, on the otherhand, though lower than public infrastructure investment in 1970-71 at 4.31 percent of GDP has increased in due course to 6.84 percent of GDP in 19921-93. A prominent crossover of private corporate investment

and public infrastructure investment was noted in 1991-92 when infrastructure investment in public sector was only 4.64 percent of GDP compared to private corporate investment at 6 percent of GDP. Non-infrastructure investment in public sector also had a similar crossover in 1991-92. After the crossover, private corporate investment reached a peak of 9.34 percent of GDP in 1996-97 when public infrastructure and non-infrastructure investment were as low as 3.84 percent and 3.82 percent of GDP respectively.

Apart from public investment, the other potential determinants of private corporate investment are output gap, rate of interest, and quantity of credit (*Equation 11*). The stylised facts related to these determinants are discussed in the following subsections.

3.2 Private Investment and Output Expectations

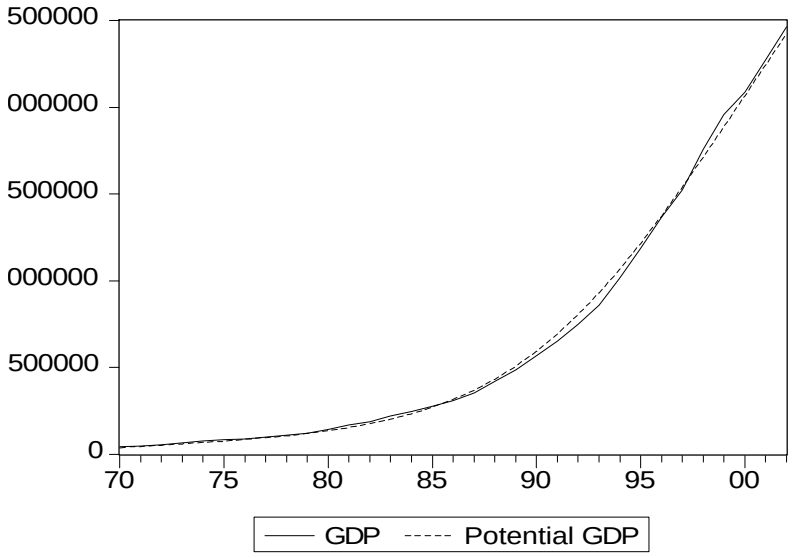
The output expectations as a determinant of private investment emanates from the accelerator theories of investment. In consistence with the flexible accelerator models of investment behaviour, *apriori* we expect that private corporate investment is determined by the output expectations in the economy, which in turn is represented most closely by the level of output gap. The *output gap* index can be defined as

OG=[(Actual GDP-Potential GDP)/Potential GDP] *100 (12)

This is also known as the 'economic activity index' (Congdon, 1998; Tanzi, 1985). It can be seen from the equation (12) that 'output gap' or the index of economic activity is defined as the difference between the actual and trend/potential level of national output as a percentage of trend/potential output.

Definitionally speaking, potential level of output would be higher than the actual as the resource utilisation is maximum at potential level. However, it is argued that cyclical factor such as recession or boom could cause the actual to be below or above the potential output respectively (Tanzi, 1985). The major problem of estimation of 'output gap' lies on t he estimation of potential level of output.[11]

Figure 4: Movement of Actual and Hodrick-Prescott Filtered Potential Output in India



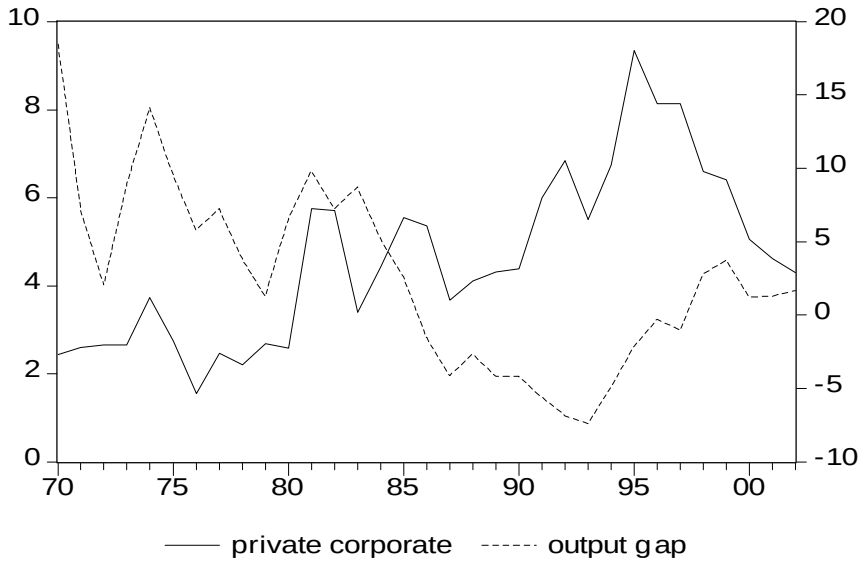
The Hodrick-Prescott filter (HP filter) is the method used in the paper for the derivation of the potential output. The idea of this filter is to decompose a non-stationary time series such as actual output into a stationary cyclical component and a smooth trend component (Y_t and Y_t^* denote the logarithms of actual and trend/potential output respectively) by minimising the variance of cyclical component subject to a penalty for variation in the second difference of the trend component. This results in the following constrained least square problem

$$Min \sum_{t=1}^{T} (Y_t - Y_t^*)^2 + l \sum_{t=2}^{T-1} [(Y_{t+1}^* - Y_t^*) - (Y_t^* - Y_{t-1}^*)]^2 \quad (13)$$

The first term in the equation is a measure of fit. The second term is a measure of smoothness. The *Langrange* multiplier λ is associated with the smoothness constraint and must be set a *priori*. As a weighting factor, it determines how smooth the resulting output series is. The lower the λ, the closer potential output follows actual output. *Figure 4* traces the path of actual and potential output in India.

The comovements of private corporate investment and output gap are given in *Figure 5*. The plot revealed that the series have shown a significant crossover in mid-eighties. After the crossover, private corporate investment increases to a peak of 9 percent of GDP in mid-nineties before it began to decline to around 4 percent of GDP in 2002-03.

Figure 5: Comovements of Output Gap and Private Corporate Investment-GDP Ratio



It is difficult to decipher from the plots whether output gap and private corporate investment are positively or negatively related. The broad trend noted from the plot is that movements of private investment have been countercyclical to output gap with a distinct crossover in mid-eighties.

3.3 Private Corporate Investment and Price vs Quantity of Credit

With regard to availability of financing, a hypothesis emerged in recent years that, in contrast to developed countries, one of the principal constraints on investment in developing countries is the quantity, rather than cost of the financial resources. This view is associated with McKinnon (1973) in his controversial work on *Money*

and Capital in Economic Development. Mc Kinnon (1973) was the first to challenge the conventional wisdom intrinsic in the Keynesian and neoclassical models that investment is interest rate sensitive and low interest rate would promote investment spending and economic growth in developed and developing countries[12] (Molho, 1986). It is noted that one of the principal constraints on investment in developing countries is the quantity, rather than the cost of financial resources, and it would be legitimate to hypothesise that private investor in a developing country is restricted by the level of bank financing (Blejer and Khan, 1984). The variable 'availability of credit' is taken in the form of annual growth rate of outstanding credit from the banking sector to the commercial sector. This variable is included in our study to understand whether it is the credit that gets rationed in the investment decisions in India. It is to be noted that moral hazards and adverse selection problems can lead to credit rationing since the riskiness of investments cannot be identified *apriori* (Stigliz and Weiss, 1981).

In order to analyse whether there is any impact of the cost of funds, [i.e., the impact of rate of interest] on private corporate investment, the study encountered the problem of selection of appropriate interest rates among the plethora of available interest rates in the financial market. The real Prime Lending Rate from the spectrum of rates of interest in India is due to its relevance in determining the investment process in the economy. The next task is to transform the Prime Lending Rate into real rate of interest.

According to Fisher hypothesis, nominal rate of interest (γ^n) is given by

$$g^n = g^r + p^e \text{ (ex-ante equation)}$$

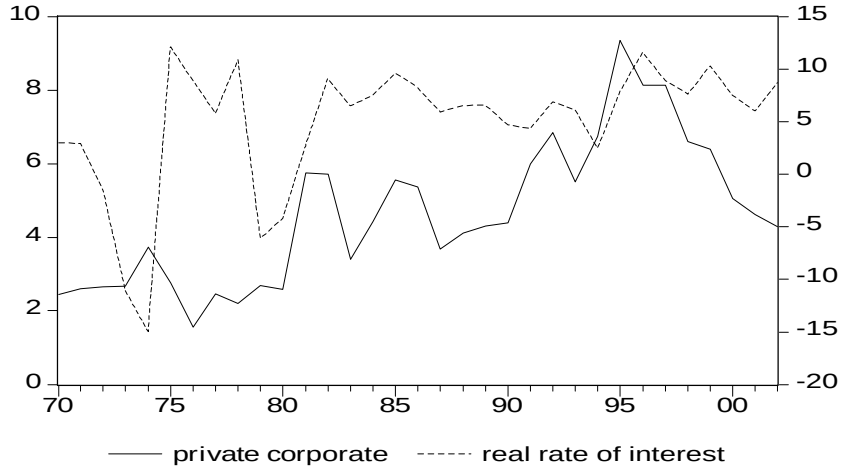
$$g^n = g^r + p \text{ (ex-post equation)}$$

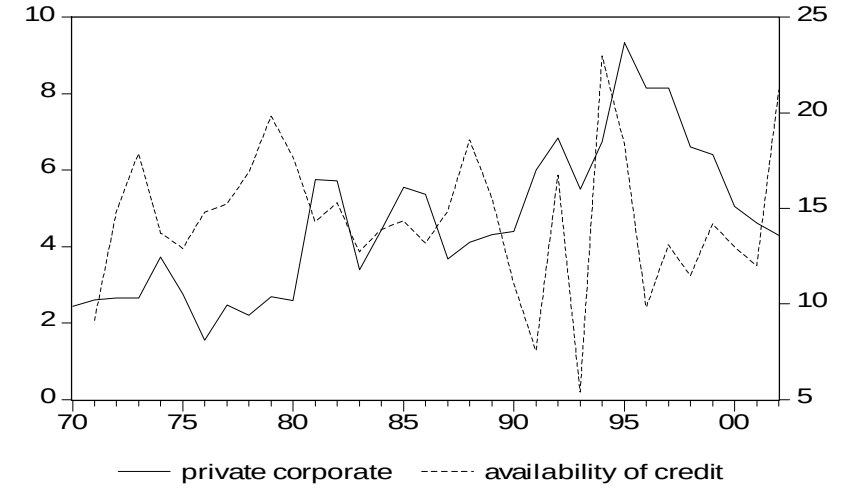
where γ^r is the ex-ante real rate of interest; p^e and p are respectively the expected and real rate of inflation . The real rate of interest in any period, thus, is postulated to evolve as a deviation between nominal rate of interest and the rate of inflation (WPI). The ex-ante real rate of interest is derived by subtracting the expected rate of inflation from the nominal rate of interest. Ex-ante real rate of interest and nominal rate of interest showed a sticky non-varying nature over the time period, though the real rate of interest, which is the difference between nominal rate of interest and nominal rate of inflation showed considerable variations in the intertemporal scale,

which motivated the study to use the real rate of interest for the analysis.

The comovements of cost and quantity of credit with private corporate investment (as percent of GDP) are given in *Figure 6*. The plots revealed the negative relationship between real rate of interest and private corporate investment; especially in the mid-nineties, private investment declined monotonically while real rate of interest remained high around a range of 8-10 percent with mid fluctuations.

Figure 6: Comovements of Cost and Quantity of Credit with Private Corporate Investment-GDP Ratio





The rate of growth of bank credit (non-food credit) to the commercial sector has shown violent fluctuations, especially since mid-eighties. A subtle positive correlation can be deciphered from the co-plots of private corporate investment and the growth rate of credit, especially in the mid-nineties which testified a falling private investment and lower growth rate of credit to the commercial sector.

3.4 Set of Stylised Facts

Before going for the econometric estimation of the model, this section attempts a quick recap of the stylised facts derived from the theoretical discussions above. The *direct* crowding out (or crowding in) can be captured from the substitution (or complementary) relationships between public and private spending that occur not through changes in prices, interest rates or required rate of return by changes in public sector activity, but through public sector consumption/investment being an argument in private utility functions and through the public sector capital stock being in argument in private sector production functions.[13] *Apriori* we anticipate a positive or negative sign for the public investment variables.

Furthermore, cost and quantity of credit variables are included in the model specification to examine the validity of Mc Kinnon hypothesis in Indian context whether it is the quantity of credit that gets rationed and not the cost of credit that matters for private investment in developing countries. This hypothesis may be set against the backdrop of the recent trends of banks in investing above the SLR (Statutory Liquidity Ratio) requirements in India. *Apriori*, real rate of interest is expected to have negative sign and availability of the credit to have positive sign in determining private capital formation. The sign of macroeconomic activity proxied by output gap is expected *apriori* to be positive or negative, depending on whether the investment decisions are pro-cyclical or countercyclical in India.

$$\underset{\quad}{I_{pvt}} = f\{\underset{(+/-),}{I_{pub},}\ \underset{(-),}{i_r,}\ \underset{(+),}{C_{pvt},}\ \underset{(+/-)}{Y^*}\}$$

IV. Econometric Estimation of the Model

Prima facie, it is difficult to understand from the plots whether the macro series under consideration are stationary or not. It is equally difficult to arrive at the conclusion whether these macroseries

have long-run stable relationship with private corporate investment. In this section, these issues will be dealt econometrically through the pre-tests of unit roots (with structural breaks) and co-integration, before proceeding to the model estimation. The paper used Hsiao's methodology for model estimation because it has got an advantage of judicious parametrisation of lag structure using Akaike's Final Prediction Error, when compared to Sims-Granger framework of causality. Also, this VAR-FPE approach does not infect the model with spurious restrictions on variables.

4.1 Checking for Stationarity of Series: Unit Root Tests with Structural Break

Testing of unit root involves the testing of order of integration of the data series. A series X_t is said to be integrated of order d, denoted by

$$X_t \sim I_t (d) \tag{14}$$

If it becomes stationary after differentiating d times, X_t contains d unit roots. Using the augmented Dickey Fuller (ADF) methodology[14], the fundamental regression equation to test unit roots is,

$$\Delta y_t = a_0 + a_1 t + a_2 y_{t-1} + \sum_{i=1}^{k} b_1 \Delta y_{t-i} + e_t \tag{15}$$

The null hypothesis of unit root is accepted if $a_2=0$. If the null hypothesis $a = a_2 = 0$ is rejected, the series is trend stationary. However, the unit root test in the presence of structural break is different from simple ADF test. Based on ADF equation, Perron (1989) developed a method to test unit roots incorporating structural change. Perron's procedure for unit roots based on modified ADF is as follows:

$$H_0: y_t = a_0 + y_{t-1} + \mu_1 D_p + \mu_2 D_L + \varepsilon_t \tag{16}$$

Where $D_p = 1$ for $t=\tau+1$, and 0 otherwise and $D_L = 1$ for $t > \tau$, and 0 otherwise. The structural break is assumed to have occurred at τ. The appropriate alternative hypothesis in this case is,

$$A_0: y_t = a_0 + a_t + \mu_2 D_L + \mu_3 D_T^* t + \varepsilon_t \tag{17}$$

Where $D_T = t - \tau$ for $t > \tau$, and 0 otherwise. In other words, the alternative hypothesis is that series is stationary around the trend, and the slope and intercept of the trend line change at $t = \tau + 1$.

Perron (1989) suggested a two-step procedure for testing unit roots in the presence of structural break.

Step 1: Detrend the data by estimating the alternative hypothesis and calling the residual y_t^r.

Step 2: Estimate the regression $y_t^r = a_2 y_{t-1}^r + e_t$

If the errors from this second regression equation do not appear to be whitenoise, estimate the equation in the form of augmented Dickey-Fuller test. The t-statistic for the null hypothesis can be compared to the Mc Kinnon critical values.

We assume a break for the macrovariables in 1991. The significance of break in trend is ascertained in terms of Chow test. The results of Chow test in terms of F-Statistic and Log Likelihood statistic revealed that all macrovariables exhibited a break in trend in 1991 (*Table 1*).

Table 1: Testing Variables for Structural Break in 1991

Macro variables	Break point	Estimated chow test F-statistic	Probability	Estimated chow test log likelihood statistic	Proba-bility
Private corporate Investment	1991	5.36	0.0100	10.39	0.0056
Public investment	1991	39.85	0.0000	43.60	0.0000
Real rate of interest	1991	48.19	0.0000	48.31	0.0000
Output gap	1991	14.24	0.0000	22.57	0.0000
Public infrastructure investment	1991	4.67	0.0175	9.21	0.0100
Public non-infrastructure Investment	1991	4.01	0.0290	8.06	0.0178
non-food credit	1991	21.06	0.0000	29.61	0.0000

The next step is to test for unit roots incorporating the structural break in 1991. The results of unit root tests incorporating the structural break of private corporate investment and its *apriori* determinants based on Perron's methodology are presented in the *Table 2*. There is no problem of seasonality as it is annual data.

Table 2: Unit Root Test Results for Private Corporate Investment and its *apriori* Determinants

Macrovariables	***Structural break at***	***ADF test statistics first-difference (without trend)***	***Order of integration***
Private corporate investment	1991	-8.028	I ~ (1) at 1%
Public investment	1991	-8.190	I ~ (1) at 1%
Real rate of interest	1991	-7.767	I ~ (1) at 1%
Output gap	1991	-5.874	I ~ (1) at 1%
Public infrastructure investment	1991	-10.670	I ~ (1) at 1%
Public non-infrastructure investment	1991	-9.1798	I ~ (1) at 1 %
Non-food credit	1991	-8.967	I ~ (1) at 1 %

Note: Campbell and Perron (1991) method is used for selecting the appropriate lags. Critical levels for first difference without trend are –2.6423 (1% level).
Source: for critical values: MacKinnon (1991)

All the variables are found stationary in first differences without trend. Dickey Fuller statistics thus imply that all variables are integrated of order one, that is, I ~ (1).

4.2 Testing for Cointegration: Johansen's Maximum Likelihood Approach

Having established that macrovariables are non-stationary and have same order of integration at I ~ (1), we test whether the linear combination of these macroseries is stationary, that is, they are cointegrated. Cointegration is a test for equilibrium between non-stationary variables integrated of same order. In case of multivariate models, Johansen's cointegration test is superior to Engle –Granger co-integration methodology for three reasons. First, the Johansen and Juselius method tests for all the number of cointegrating vectors between the variables, based on the trace statistic test. Second, it treats all variables as endogenous, thus avoiding an arbitrary choice of dependent variable. Third, it provides a unified framework for estimating and testing cointegrating relations within the framework of a vector error correction model (VECM).[15]

Johansen-Juselius tried to develop a methodology as follows to study the longrun relationship among non-stationary variables. Let us define z_t as 'n' potentially endogeneous variables and model z_t as an unrestricted VAR of k lags,

$$z_t = A_1 z_{t-1} + \text{---------} + A_k z_{t-k} + u_t \quad \text{where} \quad u_t \sim IN(0 \ \Sigma) \qquad (18)$$

where z_t is (n x 1) and each of the Ai is an (n x n) matrix of parameters.[16]

The equation (15) can be reformulated into a vector error correction (VECM) form:

$$\Delta z_t = \Gamma_1 \Delta z_{t-1} + - - - - - - - + \Pi z_{t-k} + m_t \qquad (19)$$

where Γ_i = -(I-A_1 - ------- - A_i), (I – A_1 - …….. – A_k).

and Π_i = -(I-A_1- …….. - A_k).

The equation (16) contains information on both the short run and long run adjustment to changes in z_t, via the estimates of $\hat{\Gamma}_i$ and $\hat{\Pi}$ respectively. As shown in Johansen (1988), $\Pi = \alpha\beta`$, where $\alpha$ represents the speed of adjustment to disequilibrium, while $\beta$ is a matrix of long run coefficients such that the term $\beta` z_{t-k}$ represents up to n-1 cointegrating relationships in the multivariate model which ensure that the z_t converge to their long run steady state solution.[17]

We have used trace ((λ_{trace}) test of the stochastic matrix to determine the number of cointegrating relationships, which is defined as follows:

$$l_{trace}(r) = -T \sum_{i=r+1}^{n} \ln(1 - \hat{l}_i)$$

where λ_i = estimated values of the characteristic roots (also called eigen values) obtained from the estimated π matrix; to the generalised eigen value problem $\left| l_{skk} - S_{k0} S_{00}^{-1} S_{0k} \right| = 0$

where the matrices S_{ij} are the residual moment matrices obtained from equation (19) and

T = the number of useable observations.

The empirical process of Johansen's cointegration involves the following three steps. The first step involves the determination of the optimum lag of VAR. This involves the estimation of the first differenced variables of the VAR with alternative lag lengths. The

AIC, SBC and the likelihood ratio test collectively suggest an optimal lag length of one.

Table 3: Cointegration tests based on Johansen's Maximum Likelihood Method

	No: of CE	Trace Test statistics	Critical value (5 Percent)	Critical value (1 Percent)
I	$I_{pvt} = f\{I_{pub}, i_r, C_{pvt}, Y^*\}$			
	0	98.365	59.46	66.52
	1	52.761	39.89	45.58
	2	26.455	24.31	29.75
	3	8.423	12.53	16.31
	4	0.0523	3.84	6.51
II	$I_{pvt} = \{I_{\inf\ ra}, i_r, C_{pvt}, Y^*\}$			
	0	77.949	59.46	66.52
	1	48.231	39.89	45.58
	2	26.380	24.31	29.75
	3	7.405	12.53	16.31
	4	2.632	3.84	6.51
III	$I_{pvt} = \{I_{non\inf\ ra}, i_r, C_{pvt}, Y^*\}$			
	0	88.539	59.46	66.52
	1	51.632	39.89	45.58
	2	26.850	24.31	29.75
	3	5.9454	12.53	16.31
	4	2.050	3.84	6.51

The second step involves the selection of deterministic terms in VAR. The data reveal no quadratic trend; though there is linear trend. This implies an intercept in VAR, but no trend. The third step involves the estimation of the co-integrating equations using Johansen's likelihood ratio trace ((λ_{trace}) criterion. Using non-deterministic trends, the λ- trace test suggested that the rank (number of cointegrating vectors) is three for all the three models (*Table 3*).

4.3 Causality Detection

As the macrovariables are tested for the order of integration and cointegration, the next task that follows the logical order is to detect the direction of the causality between the variables. Granger (1969) has defined causality as X_t is a Granger cause of Y_t (denoted

as $X_t \Rightarrow Y_t$) if Y_t can be predicted with accuracy by using past values of X_t rather than by not doing so, other information being identical.

The appropriate parametrisation of the model manifests the critical part of Granger-causality test, as the results depend on the lag length chosen. Arbitrary or *adhoc* parametrisation can lead to econometric problems. Under parametrisation may lead to estimation *bias* and over parametrisation results in the loss of degree of freedom and thus the power of the test.[18]

Hsiao's (1981) method is one of the alternatives to unconstrained Sims type symmetric VAR.[19] Hsiao's procedure starts from univariate autoregression and sequentially adds lags and variables using Akaike's [1969] Final Prediction Error criterion. This Asymmetric VAR model using FPE criterion to select the appropriate lag specification takes care of *parametrically prolific* symmetric VAR models. An advantage of Hsiao (1981) Asymmetric VAR is that along with the appropriate parametrisation, we can detect the causality of the variables also in the autoregressive framework. Asymmetric VAR models permit more flexibility in modeling dynamic system. In Asymmetric VAR, each equation has the same explanatory variables, but each variable may have different number of lags. Hsiao noted that, "FPE criteria is appealing since it balances the risk due to the bias when a lower order is selected and the risk due to the increase of variance when a higher order is selected." And by combining Final Prediction Error criterion and Grangers' (1969) definition of causality, a practical method for identification of the system of equations was suggested.

Vector Auto Regression models can be written in general form as

$$y_t = a + y(L)y_t + m_t \qquad (20)$$

where y_t is vector of model variables
that is, (first difference of (I_{pub}), (O_g) (i_r), ($D\,C_{pvt}$), (e_r)
α is vector of constants
μ_t is vector of white noise error terms
$\psi(L)$ is vector of polynomials in the lag operator, L
where $y_{ii} = \sum_{t-1}^{k} \Psi_{ii\,i} L^i$ where L is the lag operator and μ_t and ν_t are white noise error terms.

To choose the order of lags in ψ_{ii} (L) and ψ_{ij} (L) by the minimum FPE is equivalent to applying an approximate F test with varying significance levels (Hsiao, 1981). Akaikes' definition of Final Prediction Error criteria is expressed as

$$FPE_y(m,n) = \frac{T+m+n+1}{T-m-n-1} * \frac{s^2 y(m,n)}{T} \qquad (21)$$

where T is the number of observations, m and n are the order of lags of the variables under the concern , private corporate investment [y] and determinants[x_s] respectively and

$$s^2 y(m,n) = \sum_{t=1}^{T} (\hat{y}_t - \Psi^m{}_{ii}(L)\hat{y}_t - \Psi^n{}_i(L)\hat{x}_{(s)t} - \hat{a})^2 \qquad (22)$$

where superscripts m and n denote the order of lags in ψ_{11} (L) and ψ_{12}(L). And $\psi^m{}_{11}$ (L), $\psi^n{}_{12}$ (L) $x_{s\,t}$ and a^ are the least square estimates. The causality can be detected as follows: If FPE y (m, n) < FPE y (m, 0) then $x_{(s)t}$ Granger causes y_t, denoted by $x_{(s)t} \Rightarrow y_t$.

The final prediction error (FPE) of fitting one dimensional autoregressive process for private corporate investment is computed with upper bound of lag length (L*) assumed equal to 5 in all the models discussed in the paper. Firstly, we considered private corporate investment as controlled variable, holding the order of its autoregressive operator to one, based on FPE criteria; we sequentially added the lags of the manipulated variables such as public investment, real rate of interest, output gap, availability of credit to private sector and exchange rate upto the L* of 5 and found respective order which gives the smallest FPE.

Table 4: Public Investment –Private Investment Models: Results: Hsiao [1981] Detection of Optimal Lags of the Manipulated Variables and FPE of the Controlled Variable: 1970-71 to 2002-03

Controlled variable	**Manipulated variables**				**Optimum lags of manipulated variable**	**Final predi-ction error**	**Causality inference**
				Model I			
I_{pvt} (1)				-	-	0.0858	-
I_{pvt} (1)	$(i_r - \pi_t)$	-	-		1	0.0611	$(i_r - \pi_t) \Rightarrow I_{pvt}$
I_{pvt} (1)	$(i_r - \pi_t)$	I_{pub}	-		1	0.0409	$I_{pub} \Rightarrow I_{pvt}$
I_{pvt} (1)	$(i_r - \pi_t)$	I_{pub}	O_g		1	0.1004	$Og \neq I_{pvt}$
I_{pvt} (1)	$(i_r - \pi_t)$	I_{pub}	O_g	C_{pvt}	1	0.0337	$C_{pvt} \Rightarrow I_{pvt}$
				Model II			
I_{pvt} (1)	-	-	-	-	-		-
I_{pvt} (1)	$(i_r - \pi_t)$	-	-	-	1	0.0611	$(i_r - \pi_t) \Rightarrow I_{pvt}$
I_{pvt} (1)	$(i_r - \pi_t)$	$I_{pubinfra}$	-	-	1	0.0573	$I_{pubinfra} \Rightarrow I_{pvt}$
I_{pvt} (1)	$(i_r - \pi_t)$	$I_{pubinfra}$	C_{pvt}	-	1	0.1164	$C_{pvt} \neq I_{pvt}$
I_{pvt} (1)	$(i_r - \pi_t)$	$I_{pubinfra}$	C_{pvt}	O_g	1	0.0998	$Og \neq I_{pvt}$
				Model III			
I_{pvt} (1)	-	-	-	-	-		-
I_{pvt} (1)	$(i_r - \pi_t)$	-	-	-	1	0.0611	$(i_r - \pi_t) \Rightarrow I_{pvt}$
I_{pvt} (1)	$(i_r - \pi_t)$	$I_{pubnoninfra}$	-	-	1	0.0553	$I_{pubnoninfra} \Rightarrow I_{pvt}$
I_{pvt} (1)	$(i_r - \pi_t)$	$I_{pubnoninfra}$	C_{pvt}	-	1	0.0502	$C_{pvt} \Rightarrow I_{pvt}$
I_{pvt} (1)	$(i_r - \pi_t)$	$I_{pubnoninfra}$	C_{pvt}	O_g	1	0.0866	$Og \neq I_{pvt}$

Source: (Basic Data): *National Account Statistics*, *New Series*, CSO, various issues, and *Handbook of Statistics on Indian Economy*, RBI, various issues.
Note: Figures in the parentheses denotes the lag length of controlled variable.

The order in which variables enter into the equation is as per the *specific gravity criteria.*[20] As per the specific gravity criteria, the explanatory variables sequenced as follows in *Model 1*: real interest rate, public investment, output gap and finally credit availability to private sector. The results showed that private corporate investment is sensitive to cost and quantity of credit as well as public investment.

When the model is re-specified using public infrastructure (instead of public investment), the results did not move in tandem with the public investment model.[21] However, the specific gravity criterion of sequencing the variables into the equation suggested that real rate of interest and public infrastructure investment entered the equation prior to the variables that capture the quantity of credit and output gap. The results suggest that public sector capital formation in infrastructure and real rate of interest proved to be the effective causal factors of private corporate investment while the output gap and availability of credit were not the causal variables of the private capital formation in the corporate sector.

Similarly, the model is re-specified using public non-infrastructure (instead of public investment).[22] Theoretically, considerable ambiguity remains in the direction of magnitude of public non-infrastructure investment and private capital formation, especially in the context of developing countries. If the government invests in sectors, which are competing in nature with private firms, it may lead to crowding out of private investment. At the same time, private firms operate in a *level playing field* provided by the government in the investible sectors and government continues investing in non-infrastructure projects like manufacturing, finance and insurance, business services. A healthy co-existence of private and public sector investment can be *apriori* expected. It is therefore important to econometrically investigate whether public non-infrastructure investment have mutually reinforcing effects on private corporate investment or substitution effects. The analysis showed that public non-infrastructure investment is found significant in determining private corporate investment. Moreover, the cost of credit rather than quantity of credit are also found significant.

4.5 Error Correction Models

In addition to detection of causality, the sign and magnitude of the causal relationship between private corporate investment and other macrovariables are also of great significance in understanding the mechanism of crowding-out phenomenon. The evidence of cointegration implies the error correction modeling of private

corporate investment, which combines both the long run information and short run dynamics in the equation.

The evidence from the equation inclusive of error correction term (ecm) and a dummy for stabilisation and structural adjustment reforms since 1991 (D_{91}) revealed that public investment affect private capital formation in India (*Model 1*). There is no evidence of direct crowding out of private corporate investment by public investment; instead it is observed that one percent increase in public capital formation increased private capital formation in the corporate sector by 1.48 percent. The dummy for structural adjustment was found significant. The estimated coefficient value of error correction term of 0.322 is found significant, which suggests that the system correct its previous period's disequilibrium by 32 percent. The estimated equation reinforced the rejection of McKinnon hypothesis; as both cost and quantity of credit does matter for the capital formation in the private corporate sector in India. Though partial evidence for financial crowding out is revealed through a negative significant relationship between real rate of interest and private corporate investment; the confirmation of financial crowding out can be detected only after checking whether the real interest rate is induced by fiscal deficit operations of the government. Before going into this analysis, it is imperative to analyse the link between private corporate investment and public investment based on the non-homogeneity of public capital formation in India.

The evidence from *Model (2)* revealed that public infrastructure investment crowds in public investment; the magnitude of the effect is also substantial, that one percent rise in public infrastructure investment crowds in 1.89 percent of private corporate investment. All other variables are found insignificant, when public infrastructure is incorporated in the model instead of aggregate public investment. This result interprets that if public infrastructure is provided, investment decisions of private corporate sector does not depend on quantity and cost of credit.

The evidence from *Model (3)* revealed that cost as well as quantity of credit are significant determinants of private corporate investment. No substitution effects are observed between public non-infrastructure investment and private investment; rather the results showed that one percent increase in public capital formation in non-infrastructural sectors increased the private capital formation in the corporate sector by 1.64 percent. The coefficient of error correction term is found insignificant in the model, however the value of ecm

suggests that the system needs to adjust upward by 15 percent to restore long run equilibrium.

The above models of public (infrastructure and non-infrastructure) investment showed that there is no evidence of *direct crowding out* of private corporate investment by public investment. But the confirmation of no *financial* crowding out can be detected only after checking whether real interest rate rise is induced by fiscal deficit operations of the government.

Table 5: Error Correction Models

	C	$Dl_{pvt(t-1)}$	$Dl_{pub(t-1)}$	$Dl_{pubinfra(t-1)}$	$Dl_{pubnoninfra(t-1)}$	$D\,C_{pvt(t-1)}$	$D\,i_{r(t-1)}$	$D\,(O_g)_{t-1}$	D_{91}	$ecm_{(-1)}$	$R^2_{[DW]}$
1	-4.636 (-17.737)*	-0.039 (-1.523)	1.478 (26.323)*	-	-	1.070 (18.453)**	-1.089 (-20.143)*	-0.088 (-4.873)	0.320 (8.659)*	0.322 (11.267)**	0.99 [2.86]
2	-5.716 (-5.645)*	-	-	1.889 (1.966)***	-	0.964 (1.747)	-0.779 (-2.682)	0.180 (1.453)	-1.377 (-2.453)	-0.02 (-0.091)	0.99 [2.4]
3	-5.363 (-4.060)**	-	-	-	1.641 (9.129)*	2.210 (4.449)**	-1.343 (-4.111)**	0.346 (2.114)	0.324 (0.783)	-0.892 (-2.308)	0.99 [2.02]

Note: *, ** and *** denote significance at 1 %, 5% and 10% respectively.

However, it is to be noted that the complicated dynamics of a VAR make direct interpretation of coefficients difficult. The solution is to examine the impulse-responses. Impulse response functions are the dynamic simulations based on the estimated coefficients of VAR, which will be dealt in the following section.

4.6 Innovation Accounting: Impulse Response Functions

An impulse response function (IRF) traces the effect of one standard deviation shock to one of the innovations on current and future values of the endogenous variables through the dynamic structure of the VAR. The phenomenon of real crowding out can be detected through the dynamic effect of unit (one standard deviation) increase of public investment on the (expected) future values of private corporate investment. IRF results of the reaction of private corporate investment to shocks in public investment support the non-occurrence of crowding out. A unit policy shock to public investment increases private corporate investment by 0.04 in the initial year after the innovation and it steadily increases and reaches to 0.21 percentage points by the end of decadal simulations (*Figure 7a*).

The differential impacts of public infrastructure and non-infrastructure innovations on private corporate sector are carried out separately to analyse the non-homogeneity aspects of public investment. It is revealed that public infrastructure investment have more powerful effects than non-infrastructure. Private corporate investment reacts to one standard deviation shock to public infrastructure investment by a rise of 0.14 in the initial year and monotonically increases by 0.178 percentage points in ten years (*Figure 7b*); while responses of private corporate investment to non-infrastructure investment by the government would be only by 0.005 points in the initial year after the shock and it rose to a meagre 0.06 by the end of the decade (*Figure 7c*). These results of IRF reinforce that public investment—in particular public infrastructure investment—*crowds in* private corporate investment in the medium and long terms, which causes significant policy implications.

The dynamic simulations of private corporate investment to other macrovariables including cost and quantity of credit and output expectations revealed that the magnitude of no other variables have been as significant as public

investment in determining private corporate investment. Only one exception noted is in *Model (3)*, where the innovations to private corporate investment through the availability of credit (0.13) is more than that of non-infrastructure investment (0.06) at the end of decadal dynamic simulations (*Figure 7c*). However the dynamic simulations revealed that these credit-related innovations are found insignificant in the latter half of the decade.

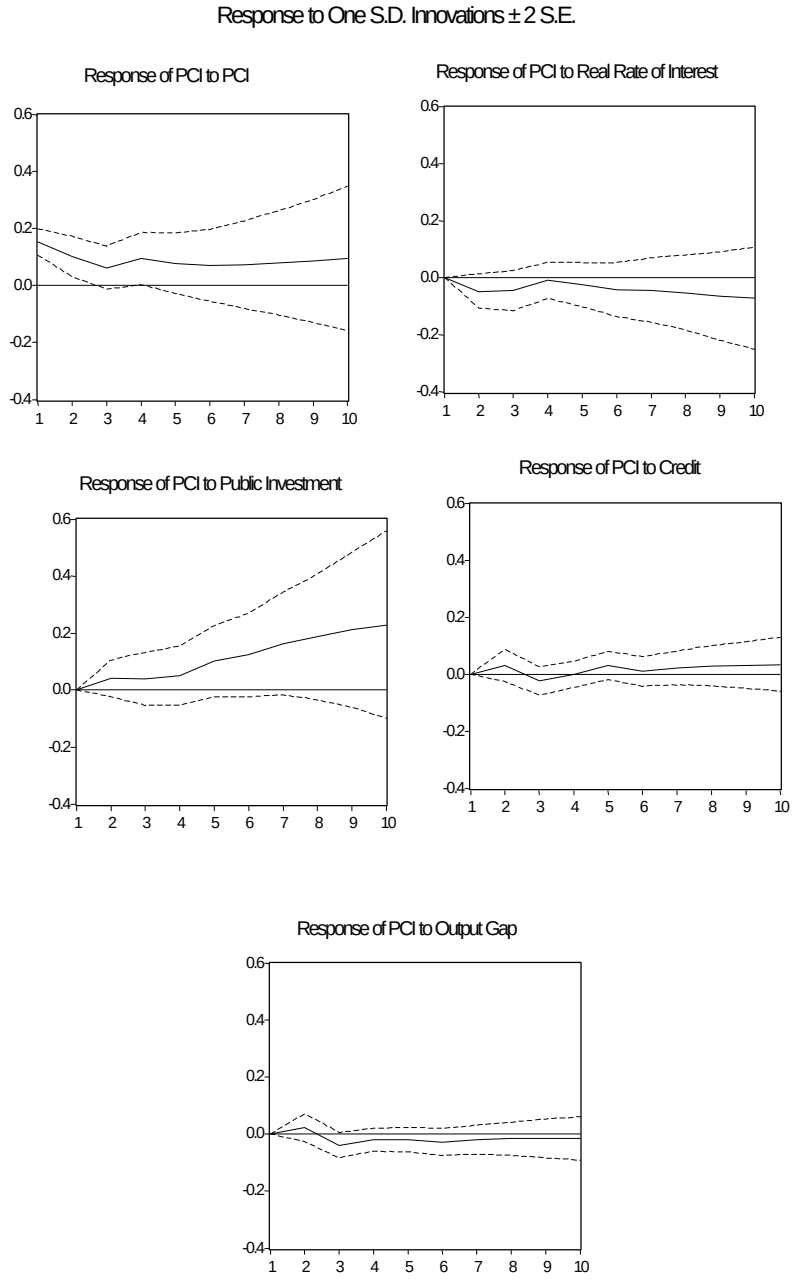


Fig 7a: Impulse Response of Model (I)

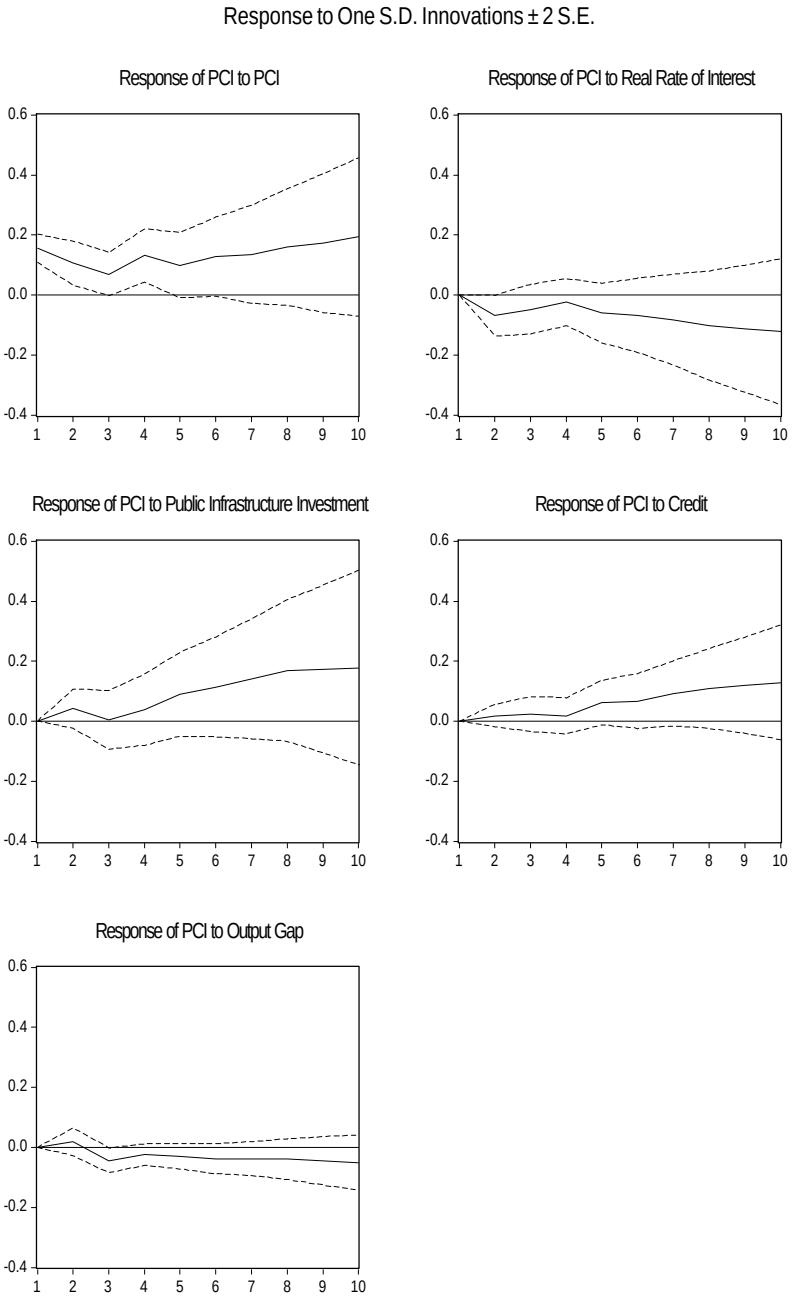


Fig 7b: Impulse Response of Model (II)

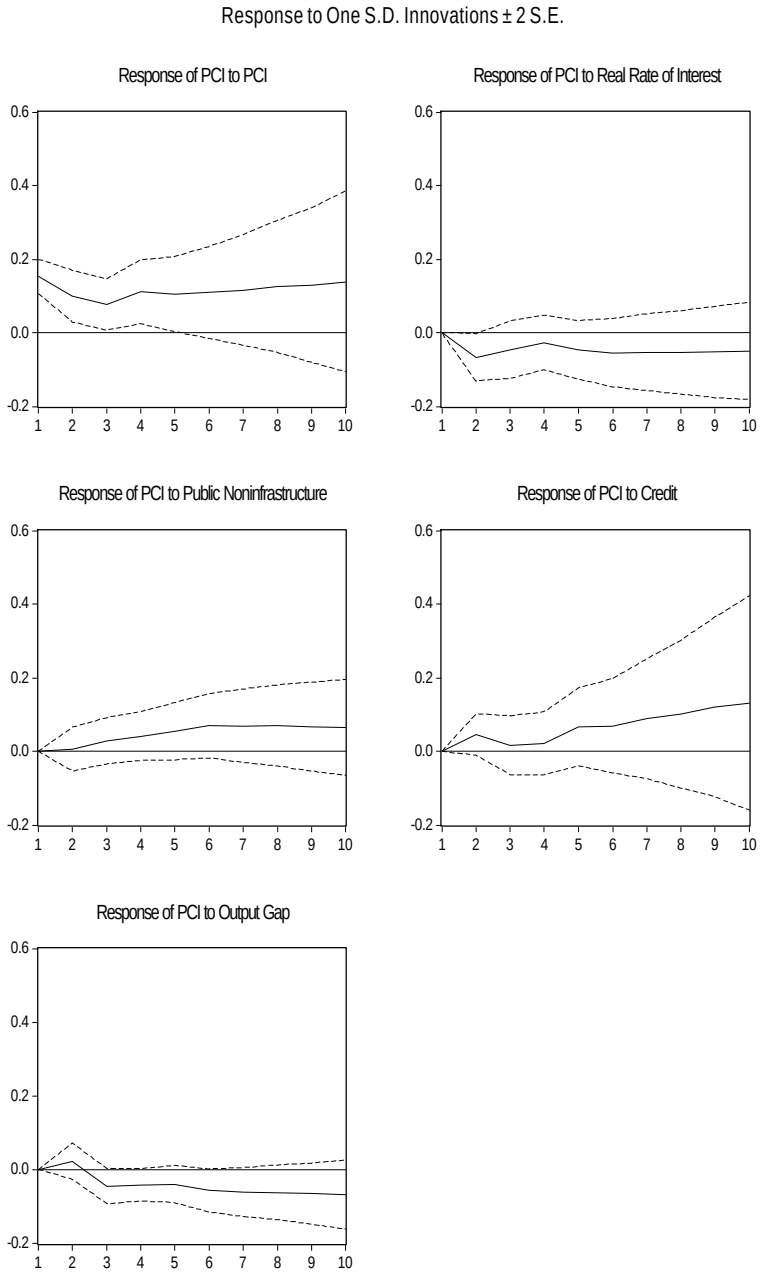


Fig 7c: Impulse Response of Model (III)

4.7 Evidence for Financial Crowding Out

Financial crowding out is advanced in literature through the testing of causal link between fiscal deficit and rate of interest (Kotlikoff, 1984). He further pointed out that much of the concern with 'financial crowding out' revolve round the transaction of selling bonds to finance fiscal deficit. As argument goes, a government's sale of bonds, regardless of its use of the proceeds, raises the total supply of bonds in the market. The greater supply of bonds, according to this view, means a lower bond price, that is, a higher interest rate, which reduces (crowds out) the private investment. The real rate of interest $(R\text{-}\pi)_t$ model is specified for India in an open economy macroframework where interest rate is determined by fiscal, monetary, and external factors. The determinants identified are expected rate of inflation (π^e_t), growth of money supply ($_{\delta}M_{3t}$), fiscal deficit (DEF_t) and exchange rate ($\$er_t$).[23] The optimal parameterisation of variables through final prediction criteria suggested that the controlled and manipulated variables take the lag structure one in real interest rate model. Also, the specific gravity criteria for ordering the variables in model allowed the entry of monetary variables prior to the entry of fiscal variables in the interest rate model.

Table 6: Real Rate of Interest Model : Hsiao [1981] Detection of Optimal Lags of he Manipulated Variables and FPE of the Controlled Variable

Controlled variable	Manipulated variables				Optimum lags of manipulated variable	Final prediction error	Causality inference
$(R-\pi)_t$ (1)	-	-	-	-	-	3.287602	
$(R-\pi)_t$ (1)	$\$er_t$	-	-	-	1	3.173645	$\$er_t \Rightarrow (R-\pi)_t$
$(R-\pi)_t$ (1)	$\$er_t$	π^e_t	-	-	1	3.235383	$\pi^e_t \Rightarrow (R-\pi)_t$
$(R-\pi)_t$ (1)	$\$er_t$	π^e_t	δM_{3t}	-	1	3.208523	$\delta M_{3t} \Rightarrow (R-\pi)_t$
$(R-\pi)_t$ (1)	$\$er_t$	π^e_t	$\Delta \delta M_{3t}$	DEF_t	1	3.452459	$DEF_t \neq (R-\pi)_t$

Note: Figures in the parentheses denotes the lag length of controlled variable.

The results shown in *Table 6* reinforced the absence of financial crowding out in India, as fiscal deficit is found insignificant in determining the real rate of interest. Instead, the results showed that real rate of interest is affected by the expected inflation, change in money supply and the exchange rate in an open economy macromodel.

Quite contrary to the crowding out debate, that is, deficit-induced rise in the rate of interest displaces private investment, our analysis proved no significant relationship between interest rate and deficit though private corporate investment is found interest rate sensitive in India. As price expectation is found to be significant, the economic fundamentals need to prevail which can in turn help in controlling the price expectations.

V. Conclusion

The results suggest that there is no evidence of *direct* crowding out of private capital formation by public investment in India. The impact of non-homogeneity of public capital formation in India on private capital formation is analysed through public infrastructure and non-infrastructure investment revealing that the former has complimentary relationship with private corporate investment and no evidence of *direct (real) crowding out* in India. Furthermore, in determining private capital formation, the rate of interest is found significant.[24]

Though there is no evidence of *direct crowding out* of private corporate investment by public investment, the confirmation of no *financial crowding out* can be detected only after analysing real interest rate rise induced by fiscal deficit operations of the government. If the real rate of interest is not induced by fiscal deficit, then there is no evidence of occurrence of *financial crowding out* though private corporate investment is interest rate sensitive. The results showed that rate of interest is not induced by the fiscal operations of the government.

The reasons for no crowding out — direct and financial — may be threefold. One of the plausible reasons for no crowding out in the context of India can be explained from the pattern of savings in the economy, especially that of the households, which has moved in favour of financial assets.[25] The conjecture is that the compositional shift in the savings in

India towards financial assets could moderate the crowding out effects, as it increases the loanable funds in the economy and thereby imparting less pressure on rate of interest.[26] The second reason could be that the increase in financial resources raised through capital markets during eighties in addition to the bank credit to private sector give an indication that private corporate sector, on the aggregate, did not face shortage of investible resources.[27] The third reason could be the overall liquidity in the system might not have pushed up the interest rate and in turn crowd out the private corporate investment.

Appendix 1: Selected Empirical Evidences on Crowding Out

Study	***Period and country***	***Model***	***Variables Selected***	***Results***
Cebula (1978)	1949-1976 US and Canada	ISLM	Capacity utilisation, lagged domestic investment, budget deficit	Budget deficit crowd out private investment in Canada and US.
Blejer and Khan (1984)	1971-1979 24 developing countries	Flexible accelerator model	Output, real bank credit, real public investment	It is not the level, but the change in public investment that crowd out private investment.
Miguel D Ramirez (1994)	1950-1990 Mexico	Flexible accelerator model	Public investment, flow of credit, exchange rate	Public investment crowds in private investment
K Krishnamurty (1985)	1975-1990 India	Sectoral model	Public infrastructure investment	Infrastructure investment crowds in private investment in almost all sectors.
Nemat Shafik (1992)	1970-1988 Egypt	Neoclassical model	Rate of interest, markup (WPI/Wage), private credit, public infrastructure, GDP.	Public investment crowds out private investment. Rate of interest determines private investment.
Greene and Villanueva (1991)	1975-1987 23 developing countries	Neoclassical model	GDP, public gross capital formation, debt ratio etc.	Gross public capital formation crowds in private investment.
Sunderrajan and Takur (1990)	1960-1978 India and Korea	Neoclassical (Jorgenson)l	Public investment, capital stock, rate of interest.	Evidence of crowding out in India. Complementary relationship between public and private investment in Korea.

Appendix 1: Selected Empirical Evidences on Crowding Out (contd..)

Study	***Period and country***	***Model***	***Variables Selected***	***Results***
B K Pradhan, D K Ratha and Atul Sarma (1988)	1960-1990 India	Computable general equilibrium (CGE) model	Interest rate, modes of financing public investment, money creation, market borrowing, taxation and mark up.	The extent of crowding out varies with the different modes of financing the public investment.
Mohanty (1995)	1960-1990 India	RET (Ricardian Equivalence Theorem)	Real disposable Income, capital stock, public debt, government expenditure, interest payments.	Direct crowding out impact of government expenditure on private consumption. Government consumption and transfer payments have positive while public investment and interest payments have negative impact on private consumption.
Karen Parker (1995)	1974 –1994 India	Accelerator model	Interest rate, public investment, credit rate, real effective exchange rate, WPI inflation, index of industrial production, GDP	Public investment crowds out private investment. Public infrastructure crowds in private investment.
K. L. Gupta (1992)	1960-1985 10 Asian Countries	RET	Transitory and permanent income, taxes, transitory and permanent government expenditure.	RET is rejected for Sri Lanka, India, Indonesia and Philippines among 10 Asian countries. Evidence of crowding out in all Asian countries except India.
Sankar (1997)	1960-1994 India	Accelerator model	Public infrastructure investment, public non-infrastructure investment, ratio of public infrastructure to non-infrastructure investment, bank rate.	Infrastructure investment crowds in private corporate investment.

Appendix 1: Selected Empirical Evidences on Crowding Out (contd..)

Study	***Period and country***	***Model***	***Variables Selected***	***Results***
Ostrosky (1997)	1950-1975 US	OSLM	Capacity utilisation rate, average profit rate, net change in the government debt etc.	Investment is affected by the net change in the debt, and hence crowding out.
Feldstein (1986)	1950-1982 Australia	Inter-temporal CGE model	Government deficit, government expenditure etc.,	Increase in debt financed proportion of government deficit crowds out private investment.
Tun Wai and Chong (1982)	1965-1975 five countries of same development pattern	Flexible Accelerator Model	Public Investment, Quantity of Credit, Private Sector Output	Public Investment crowds out Private Investment. Quantity of Credit is also a significant factor.
Alberto, Alesina (2002)	OECD countries	Tobin's Q Model	Fiscal spending (wage), Ratio of primary spending to GDP, Private Investment	Crowding out negative effect of fiscal spending – and in particular wage component – on private investment

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Endnotes

[1] Buiter (1990) also discussed the taxonomy of real (direct) and financial crowding out in detail.

[2] Economic Survey, Government of India, 2001 and the Report of Economic Advisory Council, 2001.

[3] Alternatively, higher private investment can result in lower public capital formation; for instance, firms might construct physical infrastructure such as roads, bridges themselves, thereby allowing the public sector to withhold from this investment. In other words, there exists a forward and backward linkage between private and public investment.

[4] This is because the *adhoc* configurations of demand and supply of loanable funds in the market is affected by myriad factors and these factors may have their respective role in the determination of rate of interest. But from the perspective of financial crowding out hypothesis, what is relevant is the extent to which the rate of interest is induced by the fiscal deficit operations of the government and in turn the extent to which such increase in the rate of interest adversely affect the level of private capital formation.

[5] However certain studies (for instance, Sunderrajan and Takur (1980), Tun Wai and Wong (1982), Shafik (1992), Blejer and Khan (1984), have attempted to incorporate features of standard accelerator and neo-classical models of investment through relaxation of basic assumptions underlying these models.

[6] For instance, Blejer and Khan (1984), and Tun Wai and Wong (1982).

[7] This equation requires that KP*t-1 = KPt-1.This equality would generally hold in the steady state.

[8] The paper follows the assumption of Blejer and Khan (1984) that private sector investment depends on output expectations of the economy, not in the private sector alone. Blejer and Khan (1984) also noted that private sector output is proportional to total output.

[9] Blejer and Khan (1984) hypothesised that beta coefficient depends on (i) the stage of economic cycle, (ii) the availability of financing and (iii) the level of public sector investment. While Tun Wai and Wong (1982) hypothesised beta coefficient depends positively on the change in the bank credit to the private sector and net capital inflow to the private sector.

[10] The sources of data used in the estimation of household share are varied and divergent, and as a result, the estimates contain indeterminate sources of errors. In other words, the measured trend in decrease/increase in household investment rates can be a statistical artifact, likely due to the overestimation/underestimation of private corporate investment (Little and Joshi, 1994).

[11]Theoretically, the 'production function method' estimates the trend/potential output by determining the quantity and productivity of inputs, *viz*., labour and capital. The relative importance of the two inputs are determined by assuming that their return is determined by their marginal products and their share in the national output is equal to their quantity multiplied by the return (Adams and Coe, 1990; Congdon, 1998). Trend output estimation through 'production function method' requires data on labour force and capital stock. If data on

one of these series or both are not available, one has to search for other methods of estimation of trend output. One of the most commonly used methods of estimation of trend output is the moving average method. Another method known as 'trend through peaks' developed by Klein with Wharton Econometric Forecasting Associates (hereafter TTP). The steps involved in estimation are delineated below. First step is to plot the data on GDP adjusted for price fluctuations and identify the peaks. Secondly, it is assumed that identified peaks in the series are the points where resources in the economy are used at 100 percent of their capacity. Third step is to intrapolate between the major peaks including the first and last observation. The strong assumptions beneath the TTP method itself deterred us from using it as a tool for estimating potential output.

[12] Shaw (1973) also challenged the conventional wisdom that low interest rates are adopted in the countries as a way of promoting economic growth. A detailed discussion of various rationale for a policy of low interest rates is given in Shaw (1973, pp 92-112).

[13] While the *financial* crowding out is defined as a consequence of public actions that affect private behaviour either by altering budget constraints or by influencing the prices faced by private agents, *viz*. rate of interest (Buiter, 1991). In other words, the financial crowding out is based on the notion that deficit spending *not accompanied by new issuances of money* carries with it the need for government to float debt issues which compete with the private debt instruments in financial markets (Blinder and Solow, 1973). The resulting upward pressure on interest-rates will reduce any private expenditure, which is interest-rate sensitive.

[14] One of the major problems of the ADF test is regarding the selection of appropriate lag length. Including too many lags reduces the power of the test to reject the null hypothesis since the increased number of lags require the estimation of additional parameters and loss of degrees of freedom. On the other hand, too few lags will not capture the actual error process, which would fail to give a proper estimate. (Enders: 1995). We followed the approach suggested by Campbell and Perron (1991) for the selection of appropriate lag length; that is, to start with a relatively long lag length and pare down to the model by the usual t-test and / or F-test. Thus, one can estimate the equation using a lag length of n*. If the t-statistics is insignificant in the lag n*, repeat the procedure until the last lag becomes significant.

[15] Gonzalo (1994) also pointed out that the Johansen maximum likelihood procedure for cointegration is a better technique compared to single equation methods and alternative multivariate methods.

[16] This type of VAR-model is to estimate dynamic relationships among jointly endogenous variables without imposing strong *apriori* restrictions (such as particular structural relationships and/or exogeneity of some of the variables). The system is in reduced form with each variable in zt is regressed on only lagged values of both itself and all other variables in the system. Thus OLS is an efficient way to estimate each equation comprising (i) since right hand side of each equation in the system comprises a common set of (lagged and thus predetermined) regressors (Harris, 1995).

[17] Assuming that z_t is a vector of non-stationary I(1) variables, then all the terms in (16) which involve Δz_{t-i} are I(0). We need to have u_t as I~(0) for existence of long-run relationship. This can happen only when Πz_{t-k} is stationary, which can be met in three instances: when all variables in zt are in fact stationary. The second instance when there is no cointegration, that is, Π is an (n x n) matrix of zeros. The third way for Πz_{t-k} to be I ~ (0) is when there exists upto (n-1) cointegration relationship: $\beta` z_{t-k} \sim I(0)$. In this instance, $r \leq (n-1)$ cointegration vectors exist in β (that is, r columns of β form r linearly dependent combinations of variables, each of which is stationary, together with (n-r) nonstationary vectors (that is, n-r columns of β form I ~ (1) common trends.). Only the cointegrating vectors enter equation (ii), otherwise Πz_{t-k} would not be I ~ (0), which implies that (n-r) columns of α are effectively zero. The problem of estimating the number of cointegrating vector in a multivariate system boils down to estimating the rank of Π matrix.

[18] On the basis of parametrisation, Vector Autoregressive modeling can be of two types. The first type of VAR model is standard Sims-type VAR model in which every variable enters every equation with the same lag length. This is Symmetric VAR model since it employs symmetrical lag specifications. The second type is Asymmetric VAR model. Asymmetric VAR model is defined as VAR where each variable may have a unique number of lags. The advantage of asymmetric VAR over symmetric VAR is that the latter employs the same lag length for each variable, exhausts considerable degrees of freedom, and consequently often estimates many statistically insignificant coefficients.

[19] Litterman (1986) used Bayesian Vector Autoregressive model, which is another alternative to symmetric VAR. Hsiaos' [1981] Asymmetric VAR has an advantage against Littermans' Bayesian VAR. Litterman imposes Bayesian prior restrictions on VAR coefficients. Since these prior restrictions are almost always based on forecasting performance instead of economic theory, parameter estimates from Bayesian VARs are likely to be *biased*. Bias may be acceptable in forecasting, but biased structural parameter estimates are undesirable if the goal is to answer questions about macroeconomic structure and the channels of operation of a macrovariable (Keating, 2000).

[20] Caines, *et. al*. (1981) suggested the following specific gravity criteria methodology for multivariate autoregressive modeling for stationary processes: (i). For a pair of stationary processes (X, Y) construct bivariate AR models of different orders, then compare the multivariate final prediction errors of these models, and choose the model of order k possessing minimum FPE to be the optimal model for the pair of processes (X, Y). (ii). Construct bivariate AR (k) models (both causal models and non-causal (independent) models] for (X, Y) and apply the stage wise causality detection procedure to determine the endogeneity, exogeneity or independent relations between X and Y. (iii). If a process, say X, has n multiple causal variables, $y^1, y^2, \ldots, y^n$, we rank these multiple causal variables according to the decreasing order of their specific gravities. (iv). For each caused

(endogenous) process, X, we first construct the optimal univariate AR model using FPE criterion, then we include X's multiple causal variables, one at a time, according to their causal ranks and use FPE criterion to determine the optimal orders of the model at each step (v). Pool all the optimal univariate AR models constructed in (iv) and estimate the system.

[21] Johansen's FIML estimates of cointegration based on maximum eigen value tests and trace tests revealed that there are two cointegrating equations when public infrastruture invetsment is included in the model instead of public investment. The order of cointegrating VAR is detected to be one and the models estimated on the basis of inclusion and exclusion of deterministic trends showed that the rank is two.

[22] The pretest of Johansen's FIML estimates based on maximum *eigen* value test and trace test for model re-specified using public non-infrastructure investment suggested that there are at the most two co-integrating vectors as the rank is detected two. The order of cointegrating VAR is detected to be one and the models estimated on the basis of inclusion and exclusion of deterministic trends showed that the rank is two.

[23] Chakraborty (2006) discussed the theoretical underpinnings of these determinants of rate of interest in detail.

[24] This result of rate of interest being a significant determinant of private investment is in confirmation with certain studies on crowding out in the context of developing countries including India. For instance, Shafik (1992) in the context of Italy, and Parker (1995) in the context of India.

[25] The share of financial savings in gross domestic savings has increased from 20.62 percent in 1970-71 to 48.93 percent in 1993-94 and then to 49.78 percent in 1998-99 immediately after a dip to 35.27 percent in 1995-96.

[26] It is often argued that one of the principal constraints on investment in the developing countries where prices are administratively controlled is the *credit rationing* and therefore it would be legitimate to hypothesise that private investors in developing countries are restricted by the *level of banking* (Blejer and Khan, 1984).

[27] The financing of private corporate investment through corporate debentures increased from 696 million US dollars in mid-eighties to 3,500 million US dollars by mid nineties, and equity financing of private corporate investment increased from 77 million US dollars in the late eighties to around 5,000 million US dollars by mid-nineties. Moreover, financing of private corporate sector through commercial bank borrowing also increased from 9,473 million US dollars in 1984-85 to 16,146 million US dollars by 1994-95 (*see* for details, Parker, 1995).