Macro economic effects of public investment in infrastructure in India

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Abstract

This paper attempts to build an aggregative, structural, macro-econometric model for India. Investment and output in the model are disaggregated into four sectors, viz., (a) agriculture including forestry & fishing, (b) manufacturing, (c) infrastructure, which includes power, transport, communication and construction and (d) services sector, covering all other activities. The model emphasizes the inter-relationships between internal and external balances and also the relation between money, output, prices and balance of payments. A unique feature of the model is that it incorporates the savings-investment identity. The model also tries to link economic growth with poverty reduction. Annual time series data for the period 1978-79 to 2002-03 are used for this purpose. Three-stage least squares method is used to estimate the model. The model is validated for its in-sample forecasting ability. A few counter factual policy simulations relating to public investment in infrastructure are undertaken to illustrate the usefulness of the model for analyzing the policy options in a simultaneous equations framework.

A preliminary trend analysis has shown slowing down of the economy during '90s and thereafter. There are also significant structural shifts in production from agriculture to infrastructure and services in the Indian economy. The estimated model indicated significant crowding-in effect between private and public sector investment in all the sectors. Counter factual policy simulations of sustained increase in public sector investment in infrastructure, financed through borrowing from commercial banks, shows substantial increase in private investment and thereby output in this sector. Further, due to increase in absorption, real output in the manufacturing and services sectors also seem to increase, which sets-in motion all other macro economic changes. Due to rise in sectoral (and aggregate) output, price level and money supply seem to decline in the short-run. Due to sustained nature of the policy change, the impacts get strengthened over time and benefit the economy. A 10% sustained increase in public sector investment in infrastructure, which is less than 0.4% of GDP, can accelerate the macro economic growth by nearly 2.5% without causing any inflation. Further, this increase in income will lead to nearly 1% reduction in poverty in India. This re-assures the potential for achieving the much debated 10% aggregate real GDP growth in the Indian economy.

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1. Introduction

There has been lot of public debate in recent months, particularly after the presentation of annual central budget for 2006-07 by the Finance Minister, about (a) the need for achieving 10% GDP growth and its feasibility, (b) the role and potential of infrastructure sector in achieving the desired GDP growth and (c) the ways and means of raising resources for public investment in infrastructure sector and particularly the use of accumulated foreign capital inflows for this purpose. This paper attempts to address these issues and seek quantitative answers in a macro economic theoretical framework. The tool of counter factual policy simulation, using a macro econometric model, is used for this purpose. The answers to the above questions seem affirmative as detailed below.

A macro econometric model is as a system of simultaneous equations, seeking to explain the behaviour of the key economic variables in the economy at aggregate level, based on the received theories of macroeconomics. Macro econometric modelling, in general, pursues two objectives: forecasting and policy analysis. The latter objective is the focus of this study. Fiscal and monetary policies are the foremost policies that are virtually analysed in macro econometric models from their inception.

This paper attempts to utilise the tool of an aggregative, structural, macro econometric model to analyse the macroeconomic effects of changes in selected exogenous variables for India. Before we give the details of the selected model, its estimation etc., it would be useful to briefly look at the literature on this topic pertaining to India. A detailed review of macro econometric models built for Indian economy is beyond the scope of this paper[3]. Since this study proposes to analyse the economy from a monetary framework, it would be worthwhile to look into how the monetary sector was modelled in the Indian context[4]. This will be useful for identifying the research issues pertinent to this study.

Modelling monetary sector and its links with fiscal and external sectors became a challenging task in India after 1970s. Modelling money and monetary policy for the determination of real output and price level has increased considerably in India (e.g. Rangarajan and Arif, 1990; Rangarajan and Mohanty 1997). In these

[3] A comprehensive review of macro econometric models and policy modelling for India can be found in Krishnamurty (2001), Bhattacharya et.al. (2000), and Pandit and Krishnamurty (2004).
[4] A good review of monetary sector models was provided by Jadhav (1990).

models, stock of money varies endogenously through feedback from reserve money, which changes to accommodate fiscal deficit and changes in foreign exchange reserves. The price level is determined by money supply and production. The output supply is determined as a function of real money balances and net capital stock, both with lags. Some models attempt to link the real, monetary and fiscal sectors. Models by Krishnamurty and Pandit (1985), Rangarajan and Arif (1990), and Soumya and Murty (2005) exhibit this form of linking.

Public capital expenditure adds to real capital stock, which in turn affects the level of real output. The analysis of effect of public investment on private investment indicates crowding-in (e.g. Krishnamurty, and Pandit, 1985). More recent assessment suggests the weakening of this phenomenon in the last decade possibly due to resource constraint and the negative price effect of public sector investment financed by fiscal deficit (e.g. Krishnamurty, 2001; IEG-DSE, 1999; Rangarajan and Mohanty, 1997).

Modelling the external sector was not a major concern in the earlier models, because of restrictions on trade. But, in the recent years, several models emerged with detailed emphasis on the external sector and it's interlinks with the monetary and fiscal sectors (e.g. Murty and Asha Prasuna, 1994; Soumya and Murty, 2005). Krishnamurty and Pandit (1996) modelled the merchandise trade flows in supply-demand framework and include disaggregated output, prices and investment behaviour.

Macroeconomic impact of fiscal deficit on balance of payments in India is an emerging issue in recent years since the inception of stabilization program. These issues were modelled by Rangarajan and Mohanty (1997). It is postulated that fiscal deficit increases the absorption in the economy relative to output and the output effect of deficit follows with a lag.

In a recent paper, Sastry et. al. (2003), have analysed the sectoral linkages between agriculture, industry and services in the Indian economy. The study emphasised the role of agriculture through its demand linkages with other sectors in determining the over-all growth of the economy. The next section gives a brief outline of the methodology used in the analysis.

2. Methodology

This paper tries to extend the work by the authors (Soumya and Murty, 2005), wherein they attempted to build a small macro econometric model for India using the absorption approach of Polak. Both these efforts utilize the work of Rangarajan and Mohanty (1997). Some important changes to expand that model and to address the theme of this paper have been made. The basic model is monetarist in focus. The model emphasises the inter-relationships between internal and external balances and also the relation between money, output, prices and balance of payments.

The model strives for a balance between the two polarized approaches of the classicals and the Keynesians. While classicals contend that changes in money supply, ultimately results in changes in the price level, the Keynesians on the other hand postulate that the changes in money supply eventually leads to changes in output, under conditions of less than full employment. Viewing reality lying somewhere in between these two extremes, one can postulate that changes in money supply affect both the output and the price level. Thus, the model tries to capture the effects of changes in money supply on both output and price level.

The model mainly focuses on the determination of money supply and its links with fiscal operations and on the impact of money stock on output generation. It is postulated that real money balances or credit effects output besides the real capital stock. An increase in real credit results in monetary expansion, which in turn has an effect on aggregate output and price level. A rise in output through increase in credit neutralizes the rise in price level caused by monetary expansion. Further, RBI credit to finance the resource gap, the latter defined as govt. total expenditure less govt. total receipts, causes money supply to increase endogenously with the rise in reserve money. This monetary expansion again affects the price level and output to a lesser extent, and the cycle continues.

The model also incorporates the savings-investment identity through current account balance. It also has an interest rate equation, which is in a reduced form. The interest rate determinants are changes in bank credit to commercial sector, current account balance, rate of inflation and equilibrium level of gross domestic savings. Private investment in each sector is modelled as a function of both demand and supply factors like income, public investment, public sector resource gap, real interest rate, and other shifter variables.

In addition, external sector is also modelled through demand (and supply) for exports, demand for imports and BOP identity. Assuming equilibrium in the exports market, the export supply function is specified as a price equation for unit value of exports. It incorporates world real income, relative price and the export price of the rest of the world. The export demand depends on relative export price and the real domestic income. The import demand function depends on the domestic absorption and the relative import price. The nominal exchange rate is a function of domestic price level, current account balance and the balance of payments.

In order to link the economic growth with poverty reduction, the model postulates a simple relationship between head count ratio and the per capita real income, separately in rural and urban areas. The next section looks at the trends and patterns in the data used for the econometric analysis.

3. Trends and patterns in Indian macro economy

It is important to understand the trends and patterns in the observed data, before estimating the proposed model. This provides a backdrop for interpreting the empirical results to be obtained. The data were taken from the National Accounts Statistics (NAS), published by CSO, and the Handbook of Statistics on Indian Economy, published by the RBI. The poverty estimates are based on National Sample Survey (NSS) data.

The study period taken is 1980-81 to 2002-03. For any macro econometric model, the selection of sectoral (commodity) break-up is very important and it determines the over-all size of the model. In this study, we chose a 4 commodity disaggregation for the investment and output of the real sector. These four sub-sectors are (a) agriculture including forestry & fishing, (b) manufacturing, (c) infrastructure, which includes power, transport, communication and construction and (d) services sector, covering all other activities.

Most of the variables for the real and external sectors used in the econometric analysis are in real form (constant 1993-94 prices) to avoid inflationary effects. The monetary and fiscal variables are in current prices. All price variables are indices with 1993-94 as unity. To study the macro economic trends, decade-wise annual average compound growth rates for all the variables are computed using semi-logarithmic regressions and are given in Appendix-I, Table-1. To analyse the levels of activity and changes in them, decade-wise descriptive statistics- arithmetic mean and

sectoral shares in output and investment are also given in Appendix-I, Table-2. A few variables are also plotted to understand visually the trends and fluctuations in them (Appendix-II).

Output and Prices

Real gross domestic product at factor cost, an indicator of total economic activity, grew by a moderate 5.7% p.a. during the entire study period 1980-2003. The real output growth has accelerated from 5.4% during '80s to 6.2% during '90s. Between 1993-03, the post-liberalization decade, which is also our data period for policy simulation analysis, the real output has grown at 6% p.a., a slight slowing down in the economy compared to the '90s. Real per capita output (income) also shows similar trends, after adjustment for population growth.

The above aggregate growth was made possible through differential sectoral growth: Agricultural output grew by 3%, manufacturing by 6.6%, infrastructure by 6.5% and services sector by 7.2%. Clearly, manufacturing sector has slowed-down secularly, while infrastructure and services have accelerated by about 1-1.25% p.a. This is true with the post 1990 reforms period as well. The rate of growth in the wholesale price index, in other words, rate of inflation, fluctuated between 6.6-7.8%, which declined to 5.5% during 1993-03. The national income deflator, shows similar trends but at 0.5-1% higher level.

The real GDP share in agriculture fell from 36.4% in '80s to 29.1% in '90s and it stood at 26.5% during the recent decade (1993-03), a sizable decline of 10 percentage points. The non-agriculture exhibits the opposite pattern. Within the non-agriculture, share of the services sector is the largest, accounting for more than one-third of the GDP. The share has gone-up from 32.3% in '80s to 37% in '90s and more recently to 38.8% of the GDP. The GDP share of infrastructure remained stagnant around 14-15%, although the GDP level has roughly little over doubled. The GDP share of manufacturing sector improved marginally from 17.6% in '80s to 19.4% in '90s and even subsequently. Thus, there is a structural shift in production from agriculture to infrastructure and services in the Indian economy.

Investment and savings

During 1980-03, real public investment in agriculture and manufacturing sectors has decelerated by 2.1% and 0.1% respectively, whereas real public investment in

infrastructure and services sectors grew by 3.9% and 3.7% respectively. These investment trends are consistent with the production trends discussed above. The public investment in all sectors put together grew by 2.5% in the study period. In fact, the public investment growth has decelerated from 4.5% during '80s to 2.2% during '90s. In the post-liberalization period, the growth is only 1.1%. This is the result of massive disinvestment of public sector units in the country during post-90s.

To a certain extent, private investment has substituted for public investment. Private investment in agriculture, manufacturing, infrastructure and service sectors grew by 4.2%, 7%, 5.9% and 6.3% respectively in the entire study period. Private total investment in all sectors grew by 6.3% in the study period. Between '80s and '90s, private investment accelerated in agriculture and manufacturing (substantially), but nearly stagnant or decelerated in the other two sectors. In the post-'93 period, except in agriculture, private investment slowed down in all the three other sectors. The graphs depicting investment shares also confirm this.

Nominal gross domestic savings in the economy has been growing at an average rate of 16.2% during 1980-'03, which is 0.6% faster than the growth in nominal gross investment (15.6%). However, both gross domestic savings and investment seem to have decelerated by about 4% p.a. during the recent decade[5]. These trends indicate that there has been some disillusionment in the investment climate during post-'93 period in India. The reasons could be fall in demand and recessionary conditions in the Indian economy.

Fiscal and monetary variables

In developing countries, the economic policies of the government play an important role in the growth of the economy. Govt. total expenditure consists of current and capital expenditures. The nominal total govt. expenditure has decelerated from 16.2% in '80s to 14.1% in '90s. The govt. consumption expenditure, however, accelerated from 15.4% to 16.3%. Therefore, the deceleration in govt. expenditure can solely be attributed to the deceleration in investment. These trends continue into 1993-03 period as well. Although the nominal govt. direct tax collection has accelerated, the

[5] Not with standing this deceleration in domestic savings (and investment), there are serious criticisms about the over estimation of the rate of domestic savings during recent years by the CSO (e.g. Shetty, 2005). They put the extent of over estimation around 3-4% in the savings rate during 2000-03.

total revenue seems to have decelerated. Some fiscal prudence has led to deceleration in the fiscal deficit over the years. In fact, fiscal deficit decelerated from 18.7% in ‘80s to 15.8% in ‘90s. However, it seems to have picked-up momentum again during 1993-03. Money supply grew more or less steadily at about 17% during the study period. Nominal interest rate grew marginally during ‘80s by 0.8% p.a., but dropped significantly since then and the trend continued.

External sector

Real export growth from the country has accelerated rapidly from 4.2% in ‘80s to 12% in ‘90s, with an overall growth of 9.6% p.a. Exports seems to grow even faster (12.6%) during 1993-03. The unit value of exports, proxy for export price, has increased slower during ‘80s and ‘90s, and slowed-down even further in the recent decade. The export competitiveness was facilitated by significant depreciation of Indian rupee (9.4%) against the US$, in addition to rise in unit value of exports. Despite rupee depreciation, growth in real imports has accelerated very rapidly from 6.3% in ‘80s to 15.3% in ‘90s, mainly due to higher demand. A substantial part of these imports could be POL imports, which have become essential both as inputs and final consumption goods. The import growth however seems to have slowed down to 10.7% during 1993-03. The nominal trade balance, as expected, has been negative and highly volatile, particularly during the ‘90s and thereafter. The opening-up of the economy must have been largely responsible for this.

Poverty ratios

The data on the head count (poverty) ratios, separately for rural and urban India, are taken from Radhakrishna et. al. (2004) and Panda (2006). The poverty estimates in these studies are obtained using data from the NSS, which are on calendar-year basis for some years and crop-year (July-June) for others. There are also gaps in the data for some years due to non-existence of NSS rounds. In order to match NSS rounds with NAS time series, simple average of two adjacent years is used wherever necessary. For the purpose of estimating regressions, the data are interpolated for missing years. We know that this is not a very satisfactory way, but there is no other alternative. The poverty ratios shows declining trend, though with some fluctuations, in both rural and urban areas. The fluctuations are more in the rural poverty estimates.

In summary, the above trend analysis shows that the macro economy has been under severe stress with slowing down of investment and economic growth during the '90s and thereafter. However, the infrastructure and services sectors seem to hold some hope. This paper therefore tries to look at the potential of increasing public investment in the infrastructure sector as a vehicle for accelerating economic growth and reaching the much debated 10% GDP growth in India. The following section gives the details of the estimated model.

4. Estimated Model

The proposed macro economic model consists of 4 blocks- real, fiscal, monetary and external sectors. It has 54 endogenous variables (30 equations and 24 identities) and 32 exogenous variables. For convenience of estimation and future improvements, the model is estimated in three separate modules (I, II and III) using 3SLS method for each module. The module I contains all the macro economic relationships except the real sector equations, which are put into module II. Module III has only 2 equations representing rural and urban head count (poverty) ratios. Due to lags and use of rate of change in some variables, the actual estimation uses data for 1981-82 to 2002-03.

While estimating the model, a TREND variable is included in some equations to capture the autonomous time related changes in the endogenous variables. Dummy variables are included in the model to separate the pre- and post-liberalization (1991-92 onwards) effects (Dummy2) and also to capture the abnormal fluctuations in the data for certain variables (Dummy1, Dummy3, Dummy4).

Among other things, the private investment is assumed to be explained by public sector investment in that specific sector and another important variable called 'public sector resource gap', which is defined as the difference between gross public sector savings and investment. The latter variable is common for all the four sub-sectors and expected to have a negative correlation with private investment. Based on the net effect of the above two right hand side variables on private investment, we classify whether there exists 'crowding-in' or 'crowding-out' between public and private investments. If the net effect is positive (negative), we say that there exists crowding-in (crowding-out) respectively.

The choice of the equations was guided by expected sign as well as statistical significance for the coefficients and high goodness-of-fit, including absence

of serial correlation for residuals. It may be mentioned that the choice of lag length for various determinants was also guided by expected sign and significance. It involved careful search process. The estimated model is given in the Appendix-III.

A perusal at the estimated model indicates that the model is estimated quite well. All the regression coefficients, except two, are significant at 5% or less. The signs of the coefficients also look appropriate, a priori. However, despite our best efforts, some of the equations still seem to suffer from the problem of serial correlation. In order to understand the direction and magnitude of response of each determinant on the dependent variable, the estimated mean partial elasticities of selected equations w.r.t. chosen determinants are given in Table-1. The following discussion based on the mean partial elasticities is only indicative and the net impacts measured through policy simulations later are likely to be different from these mean partial elasticities.

In this table, the first row is the agriculture production function and the entries are output elasticities with respect to factor inputs. It is important to note that there is significant dependence (complementarity) of output in agriculture on that of infrastructure. The latter commodity acts as an input to the former, particularly because it includes power as well as transport. From the table, ceteris paribus, with 1% increase in each input factor or determinant, the real aggregate agricultural output in the economy would increase by (a) 0.1% with increase in annual rainfall (b) 0.8% with increase in gross cropped area, (c) 0.8%, with one- year lag, with increase in real net capital stock in agriculture and (d) 0.2%, with one-period lag, with increase in infrastructural output respectively. The implied incremental capital-output ratio (ICOR) in agriculture is low (1.5). Thus, there exists significant (nearly unitary) supply response in Indian agriculture with respect to capital stock and sizable acreage response as well.

The real output in manufacturing would increase by 0.3% for each 1% increase in net capital stock in manufacturing sector. The implied incremental capital-output ratio is very high (13), perhaps indicative of large excess capacity. Likewise, real output in infrastructure would increase by 1.2%, with one-year lag, for each 1% increase in net capital stock in infrastructure (ICOR of 2.5). Real output in services sector would increase by 1.2% for each 1% increase in net capital stock in services sector (ICOR of 1.9). There is a significant complementarity between infrastructure and services sectors. These two sectors have elastic and nearly equal supply response

with respect to their respective capital stock. Further, the output of infrastructure seems to provide an essential input to the services sector. For each 1% increase in infrastructure output, services output will increase by 0.3%, a significant cross-complementarity.

Coming to the private investment equations, except in agriculture, public investment variable has a positive coefficient, implying complementarity between public and private investments in all the other three sectors of the Indian economy. The complementarity is most in manufacturing sector, followed by infrastructure, and services. It is interesting to notice significant cross complementarity between private investments in infrastructure and all the other three sectors as well. Specifically, 1% increase in private real investment in infrastructure increases real private investment in agriculture by 0.2% (with a one-year lag), in manufacturing by 0.1%, and in services by 0.7%, as a crowding-in effect.

One percent increase in public sector investment in manufacturing encourages private investment by 0.5%, 5.% in short- and long-run respectively. However, in infrastructure sector, private investment would increase by 0.5% (with a lag) for each 1% increase in public investment. This shows the contrasting picture between the two sectors- private sector is less enthusiastic in investing in infrastructure and perhaps expects the govt. to invest first. Further, public investment in manufacturing has sizable long-run benefits as well. Likewise, in services sector, 1% increase in public sector real investment increases private sector real investment by 0.4%, as a crowding-in effect. It is to be noted that private investment is significantly inversely correlated to real interest rate in all the four sectors, although small in magnitude. The long-run responses are even larger as expected.

From the estimated general price equation, for every 1% increase in money stock (also interest rate), the whole sale price index will go up by 0.1% and the long-run response is nearly 10 times larger. A 1% increase in real aggregate output, ceteris paribus, will decrease the whole sale price index by 0.2% in the short-run and 1.8% in the long-run. Money supply would increase by 0.2% for each 1% increase in reserve money, with money multiplier around 0.8.

Coming to government nominal revenue receipts, revenue from direct taxes will increase by 2.4% with every 1% increase in real income in the non-agriculture sector. Nominal revenue from indirect taxes increases by 0.9% for each 1% increase in aggregate nominal income and non-tax revenue increases by 1% for every 1%

increase in nominal income at market prices. Government consumption expenditure also increases by 0.2% and 2.4% with each 1% increase in nominal income in the short-run and long-run respectively. This clearly is non-sustainable, unless it is utilized very productively.

In the external sector, export demand decreases by 0.4% with 1% rise in relative price of exports (relative to world export price) and import demand falls by 0.4% with 1% rise in relative price of imports (relative to domestic whole sale price). The world income has a significant positive effect on the demand for Indian exports. Nominal bilateral exchange rate seems to increase equi-proportionally with rise in general price level. It is also positively affected by the current account balance as well as balance of payments.

From the head count ratio regressions, as expected, the head count (poverty) ratio is inversely related to per capita real income in both the areas. The estimated regressions show that for every 1% increase in per capita real income, the head count ratio, on average, will decline by 1.3% in both rural and urban areas of India. This seems to be the broad linkage between economic growth and reduction in poverty. It underlies the familiar 'trickle down' hypothesis, with all its limitations. In reality, the nature and extent of (absolute) poverty depends on several socio-economic factors, real income being only one of them.

Thus, from the signs, magnitudes, t-ratios of the coefficients and goodness of fit measures of all the equations in the model (Appendix-III), we infer that there is considerable simultaneity in the relationships and the model is indeed a simultaneous system. Further, due to both exogenous and endogenous lags, the model is truly dynamic in nature and impacts of any exogenous change will be spread over time. There will be both short- and long-run responses, which enable us to analyze counterfactual policy simulations. The next section focuses on this.

Counterfactual Policy Simulations

To assess the empirical adequacy of the full model in describing the historical data, EViews package was employed to solve the 54 relations together iteratively for each year using commonly required options, namely deterministic simulation and dynamic solving options for the entire sample period, 1981-82 to 2002-03. The simulated values for the above period are also called the 'base simulation' values. Assessment of the full model is done by (a) comparing the time

series plots of actual and base simulation values and (b) computing the summary measures, mean absolute percentage error (MAPE) and root mean square percentage error (RMPE). Based on all these three criteria, the base simulation was found to trace the historical data quite well[6](Appendix-IV, Figures:1-10). Due to limitation of space, these details are omitted here.

The main purpose of this paper is to analyze the impacts of counter factual scenarios about certain exogenous variables, including policy instruments. Hypothetical sustained[7] change(s) in each exogenous variable are incorporated for a specified sample period and the full model is solved for each year, during that sample period. The time path of each endogenous variable of such an exogenous change is compared and contrasted with the base simulation (not the actual series) as a reference path. Such comparison only can facilitate quantification of the impacts of changes in exogenous variable on the endogenous variables, without confounding the effects of the inaccuracies of estimated model.

The exogenous changes considered here include sustained increase in public sector real investment in the infrastructure sector financed either through (a) borrowing from commercial banks or (b) utilization of foreign capital inflows. These changes are envisaged to be implemented, one at a time, starting from the year 1993-94. These counterfactual simulations are undertaken to illustrate the usefulness of the model for analyzing the changes in these variables in a simultaneous equations framework. The simulation results for a few important variables are plotted in Appendix-IV, Figures: 11-18.

The allocative and dynamic macroeconomic effects due to the above exogenous/policy changes are quantified as percentage changes, also known as multipliers, with reference to base simulation values. They are reported only at four points of time, namely response in the same year of exogenous change (immediate or

[6] It may be mentioned that in simulations using multi-equation system, certain endogenous variables are likely to be systematically under/over predicted. The money supply variable got systematically under predicted here. To correct such situations, EViews package has a provision to include 'add-factors' with certain options for type of add-factor (e.g. intercept shift and endogenous variable shift) and initialization of add-factor (e.g. such that the equation has no residuals at actuals etc.). Here, the chosen options are such that the base simulation for money supply variable coincides with its historical series. This, however, will not affect the policy simulations.

[7] Some analysts prefer to hypothesise one-period or shock-type exogenous change. If the estimated underlying model is dynamically stable, the impacts of any one-period exogenous change should decay over time and all the endogenous variables return to base simulation levels. In other words, shock-type simulations are inappropriate for studying long-term policy effects. The present model confirmed this property.

instantaneous or impact), response after one year (short-term), response after five years (medium term) and response after ten years (long-term). Since the responses change each year rather slowly, the medium-term and the long-term responses are simple averages of the respective time periods. In the case of head count ratio, rate of inflation, rate of interest and trade balance, the impacts are changes in level, not rates of change. It may be mentioned that these percentage responses are contemporaneous in nature (policy simulation vs. base simulation) and should not be treated as usual percentage rate of change over time. For this reason, these responses are likely to be different from the direct responses (both partial and net) implied by the estimated equations. The ten-year period 1993-94 to 2002-03 is used for the policy simulations. The scenario results are presented in Tables: 2-3.

(a) Sustained 10% increase in public sector real investment in infrastructure sector financed through borrowing from commercial banks:

It is hypothesised that the govt. will raise the necessary investment resources through borrowing from commercial banks. In the model therefore, both the exogenous variables PCFINF and BCG are increased by 0.1*PCFINF each. This may imply that there is liquidity crunch and the bank credit that is available to commercial sector will be lesser by the amount borrowed by the govt. for investment in the infrastructure sector. Such a policy will reduce the reserve bank credit to the govt. and thereby reserve money and money supply. Changes in money supply will trigger several other changes in the economy. A sustained 10% increase in public real investment in infrastructure[8], envisaged as above, has both short- and long-run impacts on all the sectors of the Indian economy. The impacts and the dynamic multipliers are given in Table-2 and graphs comparing the baseline and policy simulated values are given in Appendix-IV, Figures 11-18.

Due to the opposite trends in public and private real investments in the agriculture sector, we got a negative sign for the lagged public investment variable. Normally, ceteris paribus, this should have meant crowding-out between private and

[8] This constitutes Rs. 3463 crores in 1993-94 and Rs. 3747 crores in 2002-03 at 1993-94 prices. These expenditures are 2.8% and 1.6% of tax revenue; 0.4% and 0.3% of GDP in respective years. From the past experience, during 1993-03, both public and private investments in infrastructure have grown at 2% p.a. The average investment growth was higher at 3.9% and 5.9% during 1980-03 in the public and private sectors. However, some analysts (e.g. Sastry et. al., 2003) believe that sustained public sector investment may not be possible under the present circumstances of resource crunch in the economy.

public investments. But, due to the presence of the 'public sector resource gap' and real interest rate variables, the net effect looks positive between public and private investments in the Indian agriculture sector as well (like in all the three other sectors) over medium to long-run. Further, agricultural sector exhibits cross-complementarity with the infrastructure sector, both in production and private investment, with a lag. This latter feature highlights the linkage between the private investment decisions of the two sectors. Thus, any change in public investment in infrastructure will not only affect private investment in that sector, with a lag, but also in agriculture and thereby rest of the economy through macroeconomic linkages.

From Table-1, it can be seen that public investment in infrastructure can affect private investment in that sector **only with a one-year lag**. This probably is due to gestation lags and delays. However, there is another important channel namely the real interest rate, which can bring about crowding-in or crowding-out depending on the magnitude of the coefficient. Thus, in the present case, a 10% increase in public investment in infrastructure in 1993-94 increased gross investment (savings) and hence the nominal interest rate fell (0.1%). But, the rate of inflation declined faster, resulting in a small increase in the real rate of interest. Hence, there was a very small crowding-out effect on private investment in that year. A similar response was noticed in the agriculture and services sectors. The aggregate private investment has therefore decreased negligibly.

Further, there are other macro economic effects. Due to increased public investment, govt. expenditure (1.3%) and fiscal deficit (4.3%) will rise. Since the govt. is envisaged to borrow the required funds from the commercial banks, the govt. may not require any support from the central bank (RBI). In fact, the RBI credit to govt. has fallen (0.2%). This results in marginal decline in reserve money, money supply (0.04%) and prices (0.1%)[9].

Due to one-period lag for net capital stock in the production function for the infrastructure sector, the output also can increase only with a lag. Due to increase in investment, aggregate demand (absorption) in the economy will increase, thereby increasing total output negligibly (0.02%), mainly due to small output growth in manufacturing (0.1%) sector. There will be a small decrease in GDP deflator (0.1%), leaving a decrease of 0.1% in nominal income. Nominal gross investment seems to

[9] In the absence of this assumption, money supply would have increased by 0.6% in 1993-94, with a similar increase in fiscal deficit (4.3%).

increase by 1.6%, exceeding the growth in nominal domestic savings (1.4%), necessitating adjustment with current account balance from the external sector.

On the fiscal side also, the impacts in 1993-94 are small, except for govt. expenditure and fiscal deficit. Higher public investment will increase govt. expenditure (1.3%). Due to decline in nominal income, there will be a small fall in revenue from indirect taxes (0.1%) and non-tax revenue (0.1%) of the govt., leaving a large uncovered fiscal deficit (4.3%). Non-market borrowings that are linked to nominal income also decline negligibly (0.1%). Demand for Indian exports will however decline (0.2%), due to rise in relative export price. But, real imports into the country will rise (0.5%) due to cheaper import prices and higher absorption. The Indian rupee appreciates marginally (0.1%) against the US$. As expected, nominal trade balance and balance of payments will worsen (0.6%).

Since the head count ratio is inversely related to per capita real income, the former declines negligibly (0.01%) due to similar increase in the latter in both rural and urban areas in 1993-94, the year of 10% increase in public investment in infrastructure. Thus, growth in income leads to decline in poverty instantaneously, though very small in magnitude.

The impacts get strengthened by 1994-95 and subsequent years. Due to crowding-in effect, 10% increase in public sector investment in infrastructure in 1993-94 encourages private real investment in infrastructure by 9%, a significant positive response of private sector. This implies a net (total) elasticity of 0.9 for private investment w.r.t. public investment in this sector. It may be noted that this response is significantly higher than the average partial elasticity (0.5) given in Table-1. Due to increase in real gross (and net) capital stock in infrastructure in 1993-94, there will be increase in infrastructure output (1.2%) this year. It is very interesting to note that private investment responds positively, in both agriculture and manufacturing sectors of the Indian economy.

Despite a small decrease in private investment in services, the aggregate real private investment is expected to rise by 1.3% and output (real income) by 0.2% in 1994-95. The nominal income also rises (0.1%). This sets-in other macro economic effects. Prominent among these are increases in govt. expenditure (1.1%), revenue (0.2%), fiscal deficit (3.3%), money supply (0.4%) and imports (0.7%). Important variables which fell are GDP deflator and price level (0.1%), real exports (0.2%), nominal exchange rate (0.2%) and trade balance (0.9%). Growth in gross domestic

savings (1.8%) continues to lag behind gross investment (2.2%), the gap bridged by current account balance.

By 1994-95, the decline in poverty gained momentum in both rural and urban areas. Due to larger increase in per capita real income, the head count (poverty) ratio declined by nearly 0.1% in both the areas. This implies that the percentage decline in poverty is roughly half the percentage increase in aggregate real income (GDP).

As expected, all these effects get strengthened further over time (since the policy is a sustained change) and lead to significant and wide spread real benefits to the economy. For example, after ten years (long-term), real gross capital stock in agricultural sector and thereby real agricultural income is expected to increase by a sizeable 1.5%, real aggregate income by 2.5%, with no perceptible increase in money supply. Despite this, the general price level is expected to fall by 1.6% and also the rate of inflation (0.3%)[10].

Real exports will continue to decline (0.6%) and imports will increase (2.1%), resulting in a significant deterioration in nominal trade balance (7.9%) and balance of payments. The current account balance is also expected to fall by the same extent. The Indian Rupee will appreciate by 2% against the US $. However, due to significant fall in prices (and GDP deflator), the nominal income increases by only 0.8%. Thus, in view of the very stagnant economic growth, sustained public investment in infrastructure can provide the necessary push to the higher growth path of the Indian economy. Further, it is interesting to note that in the long-run, the head count (poverty) ratio declined by 1.1% in rural India and 1% in urban India. This is a very significant result and offers credence to policy initiatives aimed at reducing poverty through economic growth.

(b) Sustained 10% increase in public sector real investment in infrastructure sector financed through foreign capital inflows:

In this scenario, we try to compare the earlier simulation results with an alternative policy option that is very much in recent public debate, viz. public

[10] In contrast, based on another simulation where the govt. does not borrow from the commercial banks, it is found that the money supply would have increased by 0.3%, with a significant fall in prices (1.4%) nearly same as in this scenario.

investment being financed through the accumulated foreign capital inflows. The simulation results are given in Table-3. It can be seen that the simulation results are quite similar, particularly in the long-run, with few differences in the short- and medium-term, for monetary and external sectors. Specifically, when the required funds for investment are borrowed from the capital inflows, as expected, the macro economic effects work through the external sector and money supply will increase via increased RBI credit to govt. and thereby reserve money.

Thus, in 1993-94, the year of the exogenous change, due to govt. borrowing from net capital inflows, the balance of payments will rise (1.4%) unlike in the earlier scenario. This causes the Indian rupee to depreciate rapidly (1.3%) and encourage exports demand (1.2%) from the country due to fall in relative price of exports. Equivalently, exports rise due to rise in unit value of exports as well as nominal exchange rate. Due to Rupee depreciation, real imports into the country will decline (0.1%) despite higher demand (absorption), i.e. price effect dominating the income effect. Since exports (as well as unit value of exports) rise faster than imports, the trade balance will improve (1.4%). This pattern is continued into the future until exchange rate becomes nearly stagnant and starts falling later. Unlike in the earlier scenario, money supply seems to increase (0.6%) due to increase in RBI credit to govt. to finance the investment. The general price level and inflation decline marginally. The effects on poverty reduction are identical to the earlier scenario.

The long-run effects of the two scenarios are quite similar for all the sectors. Since the required legal apparatus for the utilization of foreign capital inflows by the govt. appears not in place yet, probably, it may be easier for the govt. to borrow the required funds from the commercial banks by selling the conventional govt. security bonds. The next section gives the brief summary and broad conclusions of this study.

Summary and Conclusions

This study has analysed the likely macroeconomic effects of changes in public investment in infrastructure in India. The quantified effects include the allocative and dynamic responses of the chosen policy change on important macroeconomic variables relating to four broad sectors- real, fiscal, monetary and external sectors of the Indian economy. The real sector further decomposed into four sub-sectors, agriculture, manufacturing, infrastructure and services. The sign and magnitude of the effects vary over time- immediate to long- run.

Briefly, the estimated model indicated significant crowding-in effect between private and public sector investment in all the four sub-sectors of the real economy. This has important consequences for investment/disinvestment policies of the govt. in each of these sectors. Sustained increase in public investment in infrastructure was found to stimulate substantial increase in private investment in all the sectors. Such a policy is expected to result in wide spread benefit in the fiscal and monetary sectors of the economy. Thus, public sector investment in infrastructure sector has the potential to provide the much-needed push and accelerate the growth process of the Indian economy. A 10% sustained increase in public sector investment in infrastructure (about Rs. 3500-3800 crores p.a. at 1993-94 prices) will enable the Indian economy to grow at an additional 2.5% p.a. and achieve the much debated 10% aggregate real GDP growth per annum in the medium- to long-run. Further, such growth is non-inflationary and welfare improving through higher govt. revenue and roughly about 1% reduction in poverty. The additional expenditure is less than 0.4% of the GDP and about 2% of the tax revenue. We believe that such investment is quite feasible and cost effective.

As an alternative strategy, we simulated a policy wherein public investment in agriculture is stepped-up by an equivalent amount as in the earlier scenario combined with govt. borrowing from commercial banks. As expected, the agricultural sector exhibits rapid growth in private investment (1.9%) and output (4.9%), but the output linkages with the other three sectors are found to be much smaller. The over-all long-run growth in the real GDP is lower at only 1.5% compared to the 2.5% growth in the infrastructure scenario. The reduction in poverty is also less at 0.6-0.7% in the country. The case with public investment in manufacturing is better than that of both agriculture and infrastructure, probably due to very high long-run investment linkage. Thus, public investment in infrastructure has a higher growth potential (and reduction in poverty) than that of agriculture and even manufacturing. One important limitation of this study is the absence of sectoral price determination. The model assumes that all the output that is produced can be sold, which is clearly unrealistic.

Table-1: Estimated mean partial elasticities of some important endogenous variables w.r.t. selected determinants.

Endogenous Variable	Determinants			
YAR	**RAIN** 0.10	**AREA** 0.82	**$KAGR_{-1}$** 0.85	**$YINFR_{-1}$** 0.19
YMNR	**ADD** 0.30	**KMNR** 0.34		
YINFR	**$KINFR_{-1}$** 1.25			
YSRR	**KSRR** 1.23	**YINFR** 0.31		
PIAG	**YAR_{-1}** 0.76	**$PCFAG_{-1}$** -0.03	**$PIINF_{-1}$** 0.17	**IB (real)** -0.01#
PIMN	**PCFMN** 0.54 SR 5.02 LR	**$PIINF_{-2}$** 0.14# SR 1.35 LR	**IB_{-1} (real)** -0.10 SR -0.94 LR	
PIINF	**$PCFINF_{-1}$** 0.51	**IB (real)** -0.08		
PISR	**PCFSR** 0.40	**$PIINF_{-1}$** 0.66	**IB (real)** -0.09	
PC	**PYDR** 0.76			
CONS	**YM** 0.24 SR 2.35 LR			
DT	**YNAR** 2.39	**PGDP** 0.45		
DIT	**Y** 0.92			
NTX	**YM** 1.02			
M3	**RM** 0.21			
P	**YR** -0.19 SR -1.80 LR	**M3** 0.07 SR 0.72 LR	**IB** 0.08 SR 0.74 LR	
IB	**(Δ(BCP/P) + CAPB/P))** 0.15	**P (rate of change)** -0.03	**SAV** -0.40	
EXPT	**WYR** 0.38	**(UVIX/EXR/WPEXP)** -0.43		
IMPT	**(UVII*EXR/P)** -0.43	**AD** 0.97		
EXR	**P** 0.99	**CAB** 0.01	**BOP** 0.07	
HCRRUR	**YR/N** -1.28			
HCRURB	**YR/N** -1.27			

SR: Short-run, LR: Long-run. For definitions of variables, see pages 35-37.

Note: All the underlying regression coefficients, except two with # sign, are statistically significant at 5% or less. The elasticities are computed using the sample means of variables for the period 1993-2002.

Table-2: Impacts and dynamic multipliers (% p.a.) of 10% sustained increase in real public investment in infrastructure financed by commercial bank credit.

Variable/Year	Base* Simula-tion Level, 1993-94	Impact (1993-94)	Short-term (1994-95)	Medium-term (1995-98)	Long-term (1998-2003)
Real Sector					
Nominal Income	813.08	-0.07	0.06	0.83	0.78
GDP Deflator	0.98	-0.09	-0.13	-0.67	-1.64
Real Income	825.52	0.02	0.20	1.51	2.46
Agriculture	245.82	0.00	0.00	0.72	1.46
Manufacturing	164.34	0.10	0.18	0.60	1.07
Infrastructure	112.50	0.00	1.16	4.19	5.64
Services	302.85	0.00	0.00	1.52	2.49
Real Private Investment	110.59	-0.03	1.33	3.33	4.29
Agriculture	11.04	-0.01	0.55	1.88	2.36
Manufacturing	55.05	0.00	0.42	2.70	4.71
Infrastructure	12.94	-0.07	8.98	5.70	6.65
Services	31.55	-0.07	-0.06	3.79	3.39
Real Private Consumption	602.14	0.02	0.16	1.27	2.13
Real Personal Disposable Income	753.17	0.02	0.22	1.68	2.69
Gross Domestic Savings (N)	180.36	1.37	1.80	1.66	0.37
Gross Investment (N)	186.05	1.64	2.15	2.67	1.95
Head count ratio- rural (%) #	37.77	-0.01	-0.07	-0.62	-1.14
Head count ratio- urban (%) #	32.93	-0.01	-0.06	-0.53	-0.97
Fiscal Sector					
Govt. Consumption (N)	126.93	-0.02	0.00	0.40	0.69
Govt. Total Expenditure(N)	247.44	1.27	1.14	1.09	0.97
Govt. Revenue (N)	166.04	-0.04	0.20	1.47	1.70
Direct Taxes (N)	31.97	0.04	0.81	4.27	5.29
Indirect Taxes (N)	101.40	-0.06	0.06	0.76	0.73
Non-tax Revenue (N)	32.67	-0.07	0.06	0.84	0.79
Fiscal Deficit (N)	74.56	4.31	3.28	0.41	-0.21
Govt. Non-market Borrowings (N)	51.05	-0.07	0.06	0.83	0.78
Monetary Sector					
Money Supply	431.08	-0.04	0.44	0.49	0.03
Price Level	0.98	-0.08	-0.13	-0.64	-1.58
Rate of Inflation (%) #	8.87	-0.09	-0.05	-0.23	-0.29
Rate of Interest (%) #	12.27	-0.07	-0.04	-0.04	0.00
External Sector					
Real Exports Demand	90.36	-0.15	-0.15	-0.49	-0.60
Real Imports Demand	91.39	0.49	0.71	1.68	2.05
Unit Value of Exports	1.00	-0.01	0.00	0.01	0.07
Exchange Rate (N, Rs./$)	27.63	-0.14	-0.21	-0.90	-1.98
Trade Balance (N)#	-0.75	-0.59	-0.93	-3.76	-7.91

***: Rs. '000 crores, except GDP deflator, Price level, Rate of inflation, Rate of interest, Unit value of exports and Exchange rate. #: Changes in level.**

Table-3: Impacts and dynamic multipliers (% p.a.) of 10% sustained increase in real public investment in infrastructure financed through foreign capital inflows.

Variable/Year	Base* Simula-tion Level, 1993-94	Impact (1993-94)	Short-term (1994-95)	Medium-term (1995-98)	Long-term (1998-2003)
Real Sector					
Nominal Income	813.08	0.00	0.12	0.88	0.83
GDP Deflator	0.98	-0.04	-0.09	-0.64	-1.62
Real Income	825.52	0.03	0.21	1.53	2.49
Agriculture	245.82	0.00	0.00	0.73	1.46
Manufacturing	164.34	0.16	0.23	0.66	1.15
Infrastructure	112.50	0.00	1.16	4.19	5.65
Services	302.85	0.00	0.00	1.54	2.52
Real Private Investment	110.59	0.02	1.44	3.46	4.47
Agriculture	11.04	0.01	0.57	1.89	2.38
Manufacturing	55.05	0.00	0.54	2.92	5.05
Infrastructure	12.94	0.05	9.02	5.73	6.68
Services	31.55	0.05	0.06	3.85	3.44
Real Private Consumption	602.14	0.03	0.17	1.29	2.15
Real Personal Disposable Income	753.17	0.04	0.24	1.70	2.72
Gross Domestic Savings (N)	180.36	2.53	2.56	2.25	0.82
Gross Investment (N)	186.05	1.71	2.25	2.78	2.05
Head count ratio- rural (%) #	37.77	-0.01	-0.08	-0.63	-1.15
Head count ratio- urban (%) #	32.93	-0.01	-0.07	-0.53	-0.98
Fiscal Sector					
Govt. Consumption (N)	126.93	0.00	0.03	0.44	0.74
Govt. Total Expenditure(N)	247.44	1.29	1.17	1.12	1.00
Govt. Revenue (N)	166.04	0.02	0.26	1.53	1.75
Direct Taxes (N)	31.97	0.13	0.90	4.36	5.37
Indirect Taxes (N)	101.40	0.00	0.11	0.81	0.78
Non-tax Revenue (N)	32.67	0.00	0.12	0.89	0.84
Fiscal Deficit (N)	74.56	4.24	3.24	0.39	-0.21
Govt. Non-market Borrowings (N)	51.05	0.00	0.12	0.88	0.83
Monetary Sector					
Money Supply	431.08	0.61	0.94	0.79	0.22
Price Level	0.98	-0.03	-0.08	-0.61	-1.56
Rate of Inflation (%) #	8.87	-0.04	-0.05	-0.23	-0.30
Rate of Interest (%) #	12.27	-0.05	-0.06	-0.06	-0.02
External Sector					
Real Exports Demand	90.36	1.21	0.70	0.01	-0.34
Real Imports Demand	91.39	-0.12	0.27	1.32	1.75
Unit Value of Exports	1.00	0.19	0.03	0.06	0.11
Exchange Rate (N, Rs./$)	27.63	1.26	1.01	0.07	-1.07
Trade Balance (N) #	-0.75	1.39	0.50	-2.30	-6.12

*: Rs. '000 crores, except GDP deflator, Price level, Rate of inflation, Rate of interest, Unit value of exports and Exchange rate. #: Changes in level.

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Appendix-I

Table-1: Annual Average Compound Growth Rates (%) of important variables used in the model.

Variable	Annual Compound Growth Rate (%) during			
	(1980-89)	(1990-99)	(1980-03)	(1993-03)
Real Sector				
Nominal Income	13.9	15.2	14.5	12.4
GDP Deflator	8.1	8.5	8.4	6.1
Real Income	5.4	6.2	5.7	6.0
Agriculture	3.0	3.2	3.0	2.2
Manufacturing	7.3	6.9	6.6	5.9
Infrastructure	5.4	6.8	6.5	8.0
Services	7.1	7.9	7.2	7.9
Real Income Per Capita	3.1	4.1	3.6	4.0
Real Private Consumption	4.1	4.9	4.4	5.1
Real Personal Disposable Income	6.6	7.0	6.5	7.1
Gross Domestic Savings (N)	16.2	15.4	16.2	12.7
Gross Investment (N)	16.8	15.0	15.6	11.7
Fiscal Sector				
Govt. Consumption (N)	15.4	16.3	14.6	16.6
Govt. Total Expenditure(N)	16.2	14.1	14.3	13.8
Govt. Revenue (N)	15.9	13.6	14.1	12.1
Direct Taxes (N)	14.5	18.9	17.2	15.2
Indirect Taxes (N)	16.5	12.1	13.4	11.1
Non-tax Revenue (N)	14.7	14.2	13.8	12.2
Fiscal Deficit (N)	18.7	15.8	15.4	17.2
Govt. Non-market Borrowings (N)	19.1	15.0	14.9	19.3
Monetary Sector				
Money Supply	17.3	17.4	17.2	16.6
Price Level	6.6	7.8	7.7	5.5
Rate of Inflation (%)	-4.9	-12.7	-3.0	-10.3
Rate of Interest (%)	0.8	-1.7	-0.8	-7.5
External Sector				
Real Exports Demand	4.2	12.0	9.6	12.6
Real Imports Demand	6.3	15.3	9.8	10.7
Unit Value of Exports	9.7	7.5	9.2	3.6
Exchange Rate (N, Rs./$)	7.6	9.1	9.4	5.7
Trade Balance (N) #	3.8	79.8	8.7	47.1
Real Total Investment	4.9	6.0	4.8	1.9
Real Public Investment	4.5	2.2	2.5	1.1
Agriculture	-3.9	-0.1	-2.1	-0.8
Manufacturing	7.3	0.1	-0.1	-4.7
Infrastructure	6.4	1.8	3.9	1.9

Services	3.3	5.1	3.7	3.6
Real Private Investment	5.3	8.2	6.3	2.4
Agriculture	2.6	3.5	4.2	4.8
Manufacturing	6.0	11.7	6.9	1.0
Infrastructure	5.3	5.2	5.9	2.0
Services	5.6	4.8	6.3	4.0

Note: The annual average compound growth rate is computed using semi-logarithmic regression over time for each variable. #: In absolute value.

Table-2: Annual average for important variables.

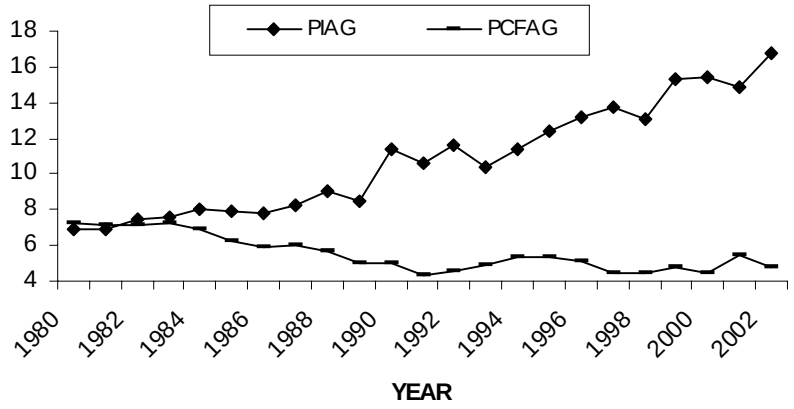
Variable/Year	Annual Average*			
	(1980-89)	(1990-99)	(1980-03)	(1993-03)
Real Sector				
Nominal Income	253.3	1053.9	839.6	1500.5
GDP Deflator	0.5	1.1	0.9	1.4
Real Income	510.7	886.9	772.2	1052.2
Agriculture	184.2	254.2	228.6	274.1
Manufacturing	90.4	172.9	146.4	206.4
Infrastructure	70.0	128.9	113.3	159.9
Services	166.1	330.9	283.9	411.8
Real Income Per Capita (Rs.)	6788	9593	8708	10750
Real Private Consumption	417.0	637.6	570.6	734.0
Real Personal Disposable Income	438.8	812.5	701.6	983.2
Gross Domestic Savings (N)	55.8	269.5	213.8	392.1
Gross Investment (N)	61.6	284.8	221.1	399.6
Fiscal Sector				
Govt. Consumption (N)	40.6	151.5	130.8	235.3
Govt. Total Expenditure(N)	82.7	310.2	256.7	452.5
Govt. Revenue (N)	54.4	208.4	167.9	294.1
Direct Taxes (N)	7.2	38.6	31.4	59.6
Indirect Taxes (N)	36.0	128.9	102.7	175.4
Non-tax Revenue (N)	11.2	40.9	33.7	59.1
Fiscal Deficit (N)	23.5	91.2	78.6	142.1
Govt. Non-market Borrowings (N)	15.6	56.1	49.4	88.0
Monetary Sector				
Money Supply	123.1	612.7	516.9	971.0
Price Level	0.5	1.1	0.9	1.4
Rate of Inflation (%)	8.0	8.1	7.6	6.1
Rate of Interest (%)	9.9	11.0	10.0	9.8
External Sector				
Real Exports Demand	45.2	112.4	99.2	161.6
Real Imports Demand	45.6	117.1	98.3	161.4
Unit Value of Exports	0.4	1.0	0.8	1.2

Exchange Rate (N, Rs./$)	11.6	31.7	24.9	39.2
Trade Balance (N)	-5.1	-13.4	-10.8	-18.4
Real Total Investment	129.5	222.4	185.7	246.0
Real Public Investment	57.5	74.3	67.7	77.8
Agriculture	6.4	4.8	5.5	4.9
Manufacturing	15.1	16.5	15.1	14.6
Infrastructure	22.0	32.8	28.9	35.5
Services	14.1	20.1	18.2	22.8
Real Private Investment	71.9	148.1	118.0	168.2
Agriculture	7.8	12.3	10.8	13.6
Manufacturing	35.0	79.6	60.2	89.0
Infrastructure	9.2	17.8	14.6	20.2
Services	19.9	38.4	32.3	45.3
Real GDP Share (%)				
Agriculture	36.4	29.1	31.5	26.5
Manufacturing	17.6	19.4	18.6	19.6
Infrastructure	13.7	14.5	14.4	15.1
Services	32.3	37.0	35.5	38.8
Real Pub. Investment Share (%)	44.8	34.2	38.5	31.8
Agriculture	5.2	2.2	3.5	2.0
Manufacturing	11.6	7.6	8.9	5.9
Infrastructure	17.0	15.2	16.0	14.6
Services	11.0	9.2	10.1	9.3
Real Pvt. Investment Share (%)	55.2	65.8	61.5	68.2
Agriculture	6.2	5.6	5.9	5.6
Manufacturing	26.6	34.8	30.8	35.9
Infrastructure	7.0	8.1	7.7	8.2
Services	15.4	17.3	17.1	18.5

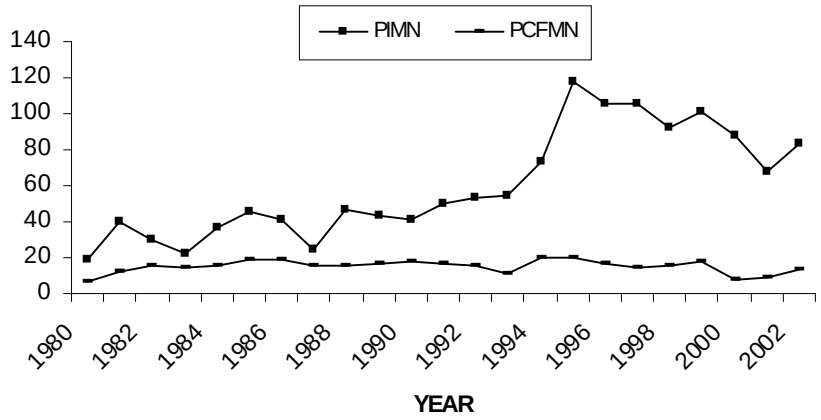
*: Rs. '000 crores, except GDP deflator, Price level, Rate of inflation, Rate of interest, Unit value of exports, which are indices and Exchange rate (Rs./$).

Appendix-II

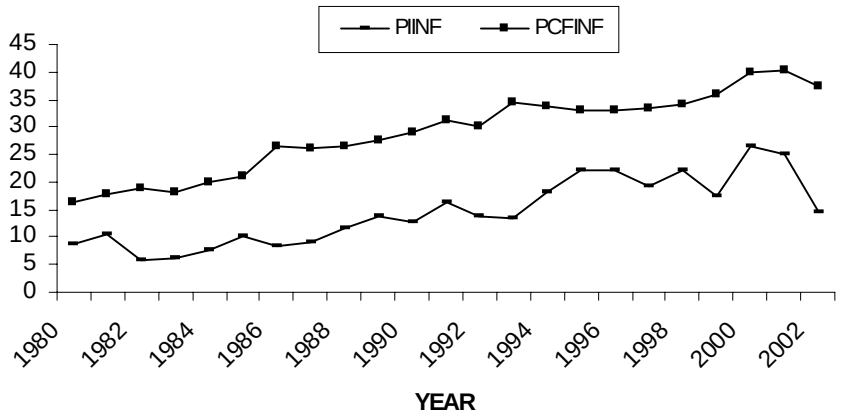
Trends in real private (PIAG) and public (PCFAG) investment in agriculture sector (Rs. '000 crores)



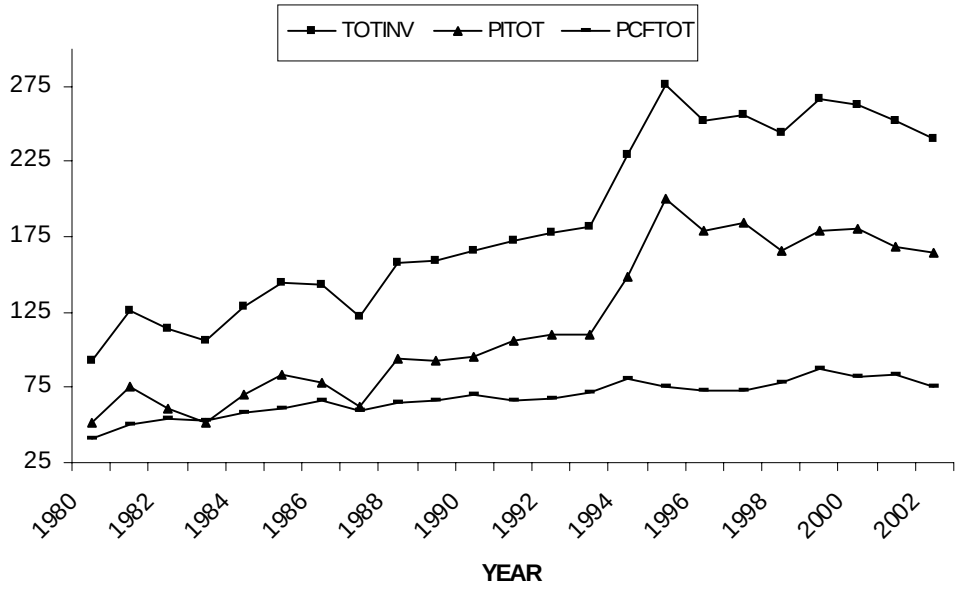
Trends in real private and public investment in manufacturing sector (Rs. '000 crores)



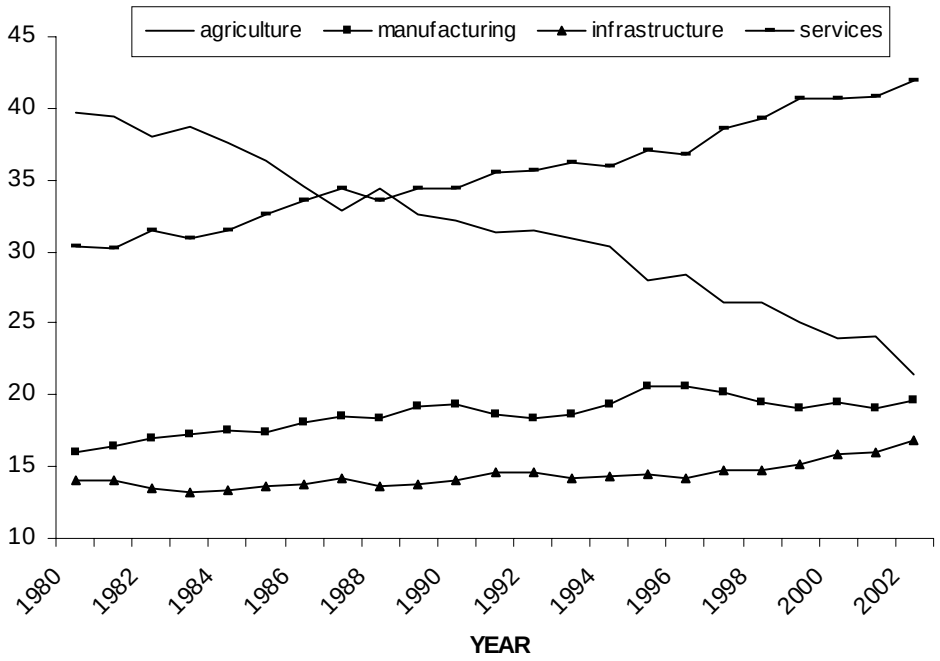
Trends in real private (PIINF) and public (PCFINF) investment in infrastructure sector (Rs. '000 crores)



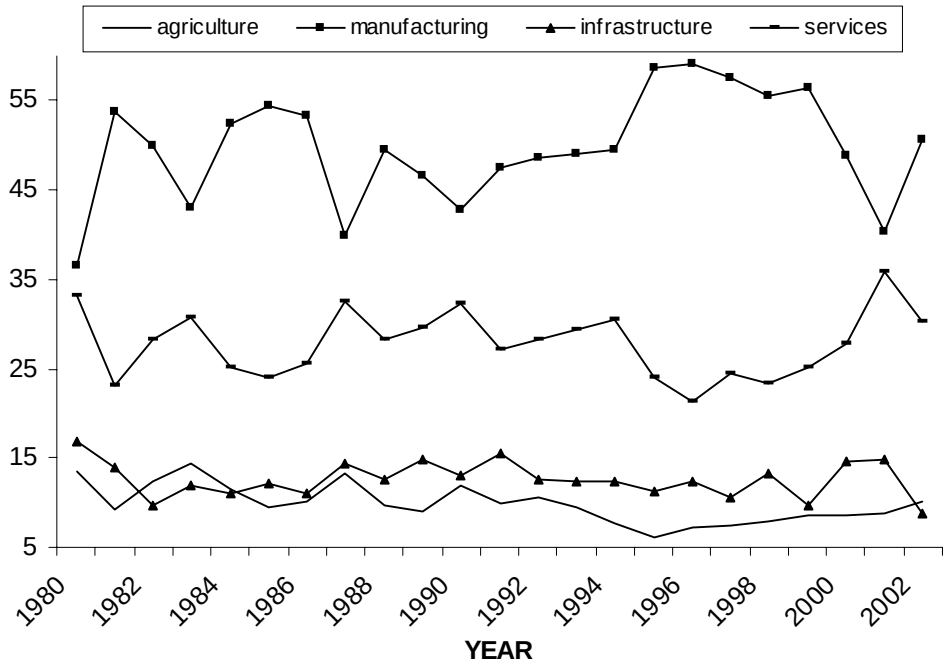
Trends in private (PITOT), public (PCFTOT) and aggregate (TOTINV) investment (Rs. '000 crores)



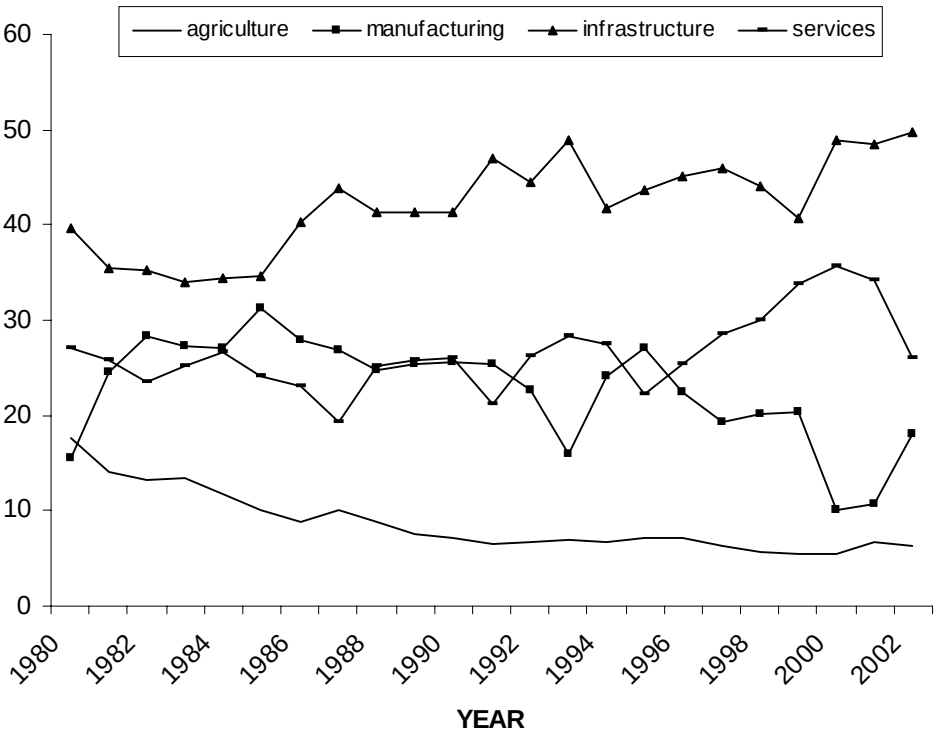
Share of sectoral real GDP in total real GDP (%)



Share of private sector investment in total investment(%)



Share of real public sector investmnet in real total investmnet(%)



Appendix-III

Estimated Model: **Period: 1981-82 to 2002-03** **Method: 3SLS**

Module-I:

Real Sector:

1. $YAR = -264.070 + 0.033\ RAIN + 226.012\ AREA + 0.672\ KAGR_{-1} + 0.351\ YINFR_{-1}$
(-13.44) (3.80) (8.01) (16.81) (10.04)

$- 0.494\ AR(1)$
(-3.66)

$\bar{R}^2 = 0.99$ DW = 2.08

2. $YMNR = 0.054\ ADD + 0.076\ KMNR + 3.644\ TREND + 0.521\ AR(1)$
(3.82) (3.87) (3.98) (3.55)

$\bar{R}^2 = 0.99$ DW = 1.38

3. $YIFR = -33.253 + 0.404\ KIFNR_{-1} - 14.892\ DUMMY1$
(-7.68) (36.04) (-7.15)

$\bar{R}^2 = 0.98$ DW = 0.57

4. $YSRR = -206.22 + 0.520\ KSRR_{-1} + 0.847\ YINFR_{-1} - 13.820\ DUMMY2$
(-9.13) (7.97) (3.17) (-3.94)

$\bar{R}^2 = 0.99$ DW = 1.10

5. $PIAG = 0.039 YAR_{-1} - 0.081 PCFAG_{-1} + 0.114\ PIINF_{-1} - 0.04\ (IB-((P-P_{-1})*100/P_{-1}))$
(17.05) (-1.99) (5.51) (-1.91)

$- 0.019\ (PCFSAV_{-1}/PGKE_{-1} - PCFTOT_{-1}) - 0.542\ AR(1)$
(-5.31) (-5.37)

$\bar{R}^2 = 0.96$ DW = 1.92

6. $PIMN = -50.616 + 3.294\ PCFMN + 0.668\ PIINF_{-2} - 2.516\ (IB-((P-P_{-1})*100/P_{-1}))$
(-8.02) (11.90) (1.89) (-8.54)

$- 0.098\ (PCFSAV_{-1}/PGKE_{-1} - PCFTOT_{-1}) + 0.893\ PIMN_{-1} - 0.330\ AR(1)$
(-2.06) (14.56) (-3.74)

$\bar{R}^2 = 0.82$ DW = 1.94

7. $PIINF = 0.294\ PCFINF_{-1} - 0.106\ (PCFSAV_{-1}/PGKE_{-1} - PCFTOT_{-1})$
(3.40) (-2.90)

$- 0.469\ (IB-((P-P_{-1})*100/P_{-1})) + 8.176\ DUMMY3$
(-2.54) (5.81)

$\bar{R}^2 = 0.76$ DW = 1.64

8. PISR = 0.793 PCFSR + 1.488 $PIINF_{-1}$ – 1.118 (IB-((P-P_{-1})*100/P_{-1}))
(12.52) (16.34) (-7.53)

$\bar{R}^2 = 0.89$ DW = 1.30

9. DEPAG = -11.956 + 0.076 $KAGR_{-1}$ + 0.641 AR (1)
(-9.37) (19.70) (9.37)

$\bar{R}^2 = 0.99$ DW = 1.32

10. DEPMN = 15.098 + 0.037 $KMNR_{-1}$ + 0.183 AR (1)
(4.36) (7.16) (4.99)

$\bar{R}^2 = 0.71$ DW = 1.97

11. DEPINF = - 4.414 + 0.079 $KINFR_{-1}$ - 0.258 AR (1)
(-4.26) (30.30) (-3.62)

$\bar{R}^2 = = 0.95$ DW = 1.64

12. DEPSR = -6.082 + 0.034 $KSRR_{-1}$
(-3.77) (17.09)

$\bar{R}^2 = 0.91$ DW = 1.30

13. PC = 174.285 + 0.568 PYDR + 0.571 AR (1)
(26.24) (68.08) (6.10)

$\bar{R}^2 = 0.99$ DW = 1.56

14. PDYR = -105.873 + 1.040 YR + 0.632 AR (1)
(-6.02) (52.80) (8.66)

$\bar{R}^2 = 0.99$ DW = 1.62

Module-II:

Fiscal Sector:

15. DT = -33.635 + 0.183 YNAR + 19.267 PGDP - 3.710 TREND
(-37.17) (23.01) (3.80) (-15.28)

$\bar{R}^2 = 0.99$ DW = 1.51

16. DIT = 13.648 + 0.108 Y + 0.550 AR (1)
(3.99) (39.03) (5.02)

$\bar{R}^2 = 0.99$ DW = 2.10

17. NTX = 0.036 YM + 0.279 AR (1)
(61.20) (1.99)

$\bar{R}^2 = 0.99$ DW = 1.78

18. CONS = 0.035 YM – 5.746 DUMMY2 + 0.896 $CONS_{-1}$
(5.80) (-2.38) (22.47)

$\bar{R}^2 = 0.99$ DW = 2.33

19. DNB = 0.063 Y + 0.725 AR (1)
(11.67) (6.99)

$\bar{R}^2 = 0.95$ DW = 2.13

Monetary Sector:

20. M3 = 0.831 RM – 9.380 TREND + 1.145 AR (1)
(3.99) (-2.03) (108.32)

$\bar{R}^2 = 0.99$ DW = 2.50

21. P = -0.0002 YR + 0.0001 M3 + 0.011 IB + 0.897 P_{-1} + 0.012 TREND
(-4.83) (4.59) (6.62) (26.09) (8.36)

$\bar{R}^2 = 0.99$ DW = 1.78

22. PGDP = -0.067 + 1.072 P + 0.579 AR (1)
(-4.99) (79.81) (9.44)

$\bar{R}^2 = 0.99$ DW = 1.44

23. PGKE = 0.954 P + 0.833 AR (1)
(48.15) (14.59)

$\bar{R}^2 = 0.99$ DW = 2.10

24. IB = 8.012 + 0.014 (Δ(BCP) +CAPB) – 4.781 ((P-P (-1))/P (-1)) – 0.010 SAV
(24.20) (3.12) (-2.78) (-5.88)

+ 2.90 DUMMY2 + 2.660 DUMMY4
(13.54) (11.98)

$\bar{R}^2 = 0.87$ DW = 1.64

External Sector:

25. EXPT = 210.703 – 2866.868 (UVIX/EXR/WPEXP) + 0.0007 WYR
(6.48) (-4.01) (4.04)

- 68.846 DUMMY4
(-7.54)

$\bar{R}^2 = 0.94$ DW = 1.28

26. UVIX = – 4.269 (P/EXR) + 9.45E-06 WYR + 0.521 WPEXP – 0.001 $EXPT_{-1}$
(-6.54) (20.20) (14.96) (-5.22)

$\bar{R}^2 = 0.99$ DW = 2.14

27. IMPT = – 1.890 (UVII*EXR/P) + 0.120 AD – 4.812 TREND
(-5.59) (8.58) (-4.04)

+ 0.395 (TREND*TREND) + 0.484 AR (1)
(14.61) (3.91)

$\bar{R}^2 = 0.99$ DW = 1.61

28. EXR = - 3.015 + 28.478 P – 0.067 CAB + 0.093 BOP + 0.292 AR (1)
(-4.06) (31.28) (-2.85) (5.19) (2.48)

$\bar{R}^2 = 0.99$ DW = 1.58

Module-III:

Poverty ratios:

29. HCRRUR = 69.672 – 38.895 (YR/N) + 4.098 DUMMY2 + 0.446 AR (1)
(16.13) (-7.57) (2.60) (2.67)

$\bar{R}^2 = 0.88$ DW = 2.15

30. HCRURB = 63.569 – 33.105 (YR/N) 0.338 AR (1)
(29.55) (-14.30) (2.01)

$\bar{R}^2 = 0.96$ DW = 2.31

Identities:

1. PYD = PYDR * P
2. Y = YR * PGDP
3. YR = YAR + YNAR
4. YNAR = YMNR + YINFR + YSRR
5. YM = Y+DIT+YMDIFF
6. KAGR = $KAGR_{-1}$ + PIAG + PCFAG – DEPAG+RES1
7. KMNR = $KMNR_{-1}$ + PIMN + PCFMN - DEPMN
8. KINFR = $KINFR_{-1}$ + PIINF + PCFINF - DEPINF
9. KSRR = $KSRR_{-1}$ + PISR + PCFSR - DEPSR
10. PCFTOT = PCFAG + PCFMN + PCFINF + PCFSR
11. PITOT = PIAG + PIMN + PIINF + PISR
12. ABSP = PC + PITOT
13. ADD = ABSP + (CONS / P) + PCFTOT + EXPT – IMPT

14. AD = ADD + IMPT
15. GCF = GCFDIFF + (PCFTOT + PITOT) * PGKE
16. SAV = GCF - CAPTR + CAB
17. GXP = CONS + TRP + PCFTOT * PGKE
18. TR = DT + DIT + NTX
19. FD = GXP - TR - ORV
20. D (RCG) = FD - D (BCG) - DNB - EB – MISCR
21. RM = RCG + RBCS + RBFA + GCL - RNML + MISL
22. BCP = M3 - RCG - BCG - RBFA - GCL + RES
23. CAB = UVIX * EXPT - UVII * IMPT + ER
24. BOP = CAB + FDI + NIF

Endogenous variables (Rs. '000 Crores):

1. ABSP: Real Private Absorption
2. AD: Real Aggregate Absorption
3. ADD: Real Aggregate Demand
4. BCP: Bank Credit to Commercial Sector (Nominal)
5. BOP: Balance of payments (Nominal)
6. CAB: Current account balance (Nominal)
7. CONS: Government Consumption Expenditure (Nominal)
8. DEPAG: Real Depreciation in Agriculture
9. DEPINF: Real Depreciation in Infrastructure
10. DEPMN: Real Depreciation in Manufacturing
11. DEPSR: Real Depreciation in Services
12. DIT: Indirect taxes of both central and state govts. (Nominal)
13. DNB: Government Non-Market Borrowings of both central and state govts. (Nominal)
14. DT: Direct taxes of both central and state govts. (Nominal)
15. EXPT: Real Exports
16. EXR: Exchange Rate against US $ (Nominal, Rs. /$)
17. FD: Fiscal Deficit of both central and state govts. (Nominal)
18. GCF: Gross domestic capital formation, adjusted series (Nominal)
19. GXP: Government Total Expenditure of both central and state govts. (Nominal)
20. IB: Nominal Interest Rate (%) on 3-Year bank deposits
21. IMPT: Real Imports
22. KAGR: Real Net Capital Stock in Agriculture
23. KMNR: Real Net Capital Stock in Manufacturing
24. KINFR: Real Net Capital Stock in Infrastructure
25. KSRR: Real Net Capital Stock in Services
26. M3: Money Supply (Nominal)
27. NTX: Non-tax revenue of both central and state govts. (Nominal)
28. P: Wholesale Price Index (1993-94=1.0)
29. PC: Real Private Consumption
30. PCFTOT: Real Aggregate Public Investment
31. PITOT: Real Aggregate Private Investment
32. PGDP: GDP deflator (1993-94=1.0)
33. PGKE: Gross investment deflator (1993-94=1.0)
34. PIAG: Real Gross Private Investment in Agriculture

35. PIINF: Real Gross Private Investment in Infrastructure
36. PIMN: Real Gross Private Investment in Manufacturing
37. PISR: Real Gross Private Investment in Services
38. PYDR: Real Disposable Income
39. PYD: Personal Disposable Income (Nominal)
40. RCG: Reserve bank credit to the govt. (Nominal)
41. RM: Reserve money (Nominal)
42. SAV: Gross domestic savings (Nominal)
43. TR: Government Current Revenue of both central and state govts. (Nominal)
44. UVIX: Unit Value of Exports (1993-94=1.0)
45. Y: Nominal Output at factor cost
46. YAR: Real Output in Agriculture
47. YINFR: Real Output in Infrastructure
48. YM: Gross Domestic Product at Market Prices (Nominal)
49. YMNR: Real Output in Manufacturing
50. YNAR: Real Output in Non-Agriculture Sector
51. YSRR: Real Output in Services
52. YR: Real Output at factor cost
53. HCRRUR: Head count ratio in rural areas (%)
54. HCRURB: Head count ratio in urban areas (%)

Exogenous Variables (Rs. '000 Crores):

1. AREA: Index of Gross Cropped Area (1993-94=1.0)
2. BCG: Bank Credit to Government (Nominal)
3. CAPB: Net capital account in the balance of payments (Nominal)
4. CAPTR: Capital transfers to govt.
5. DUMMY1: Dummy for sharp increase in output of Infrastructure (1993-98)
6. DUMMY2: Dummy for post reform period (1991-92 onwards)
7. DUMMY3: Dummy for sharp decline in Inflation (post '90s)
8. DUMMY4: Dummy for sharp increase in exports (1999 onwards)
9. ER: Current Account Balance excluding Trade Balance
10. FDI: Foreign Direct Investment (Nominal)
11. GCL: Government current liabilities to the public (Nominal)
12. MISCR: Other components of RBI credit to govt.
13. MISL: Miscellaneous components of Reserve Money
14. NIF: Net Capital Inflows (Nominal)
15. ORV: Other Revenues (Nominal)
16. PCFAG: Real Gross Public Investment in Agriculture
17. PCFINF: Real Gross Public Investment in Infrastructure
18. PCFMN: Real Gross Public Investment in Manufacturing
19. PCFSR: Real Gross Public Investment in Services
20. PCFSAV: Gross Public Sector Savings (Nominal)
21. RAIN: Annual Rainfall (mm)
22. RBCS: RBI credit to the commercial sector (Nominal)
23. RBFA: Net Foreign Exchange Assets of RBI (Nominal)
24. RES: Residual components of Bank credit to commercial sector
25. RES1: Residual for net capital stock in agriculture
26. RES2: Residual for net capital stock in non-agriculture

27. RNML: RBI's net non-monitory liabilities (Nominal)
28. TRP: Transfer payments
29. UVII: Unit Value of Imports (1993-94=1.0)
30. WPEXP: World Price Index (1993-94=1.0)
31. WYR: Real World Income
32. NTOT: Aggregate population (millions)

Appendix-IV

Figure-1: Actual and baseline values of real output

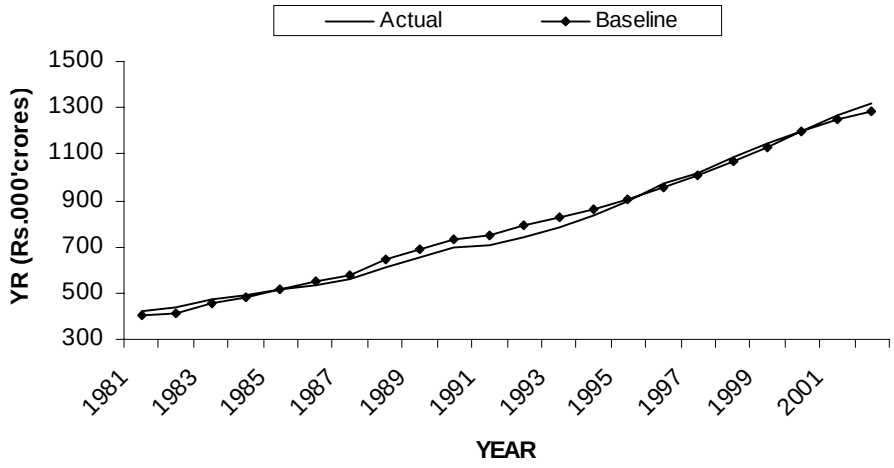


Figure-2: Actual and baseline values of real private consumption

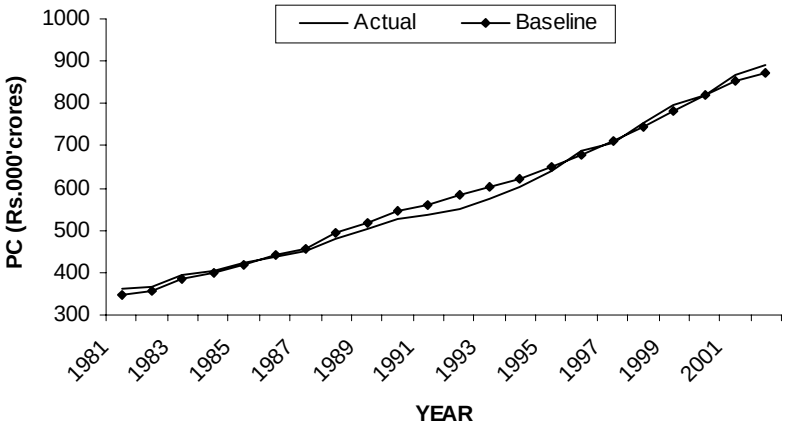


Figure-3: Actual and baseline values of nominal govt. revenues

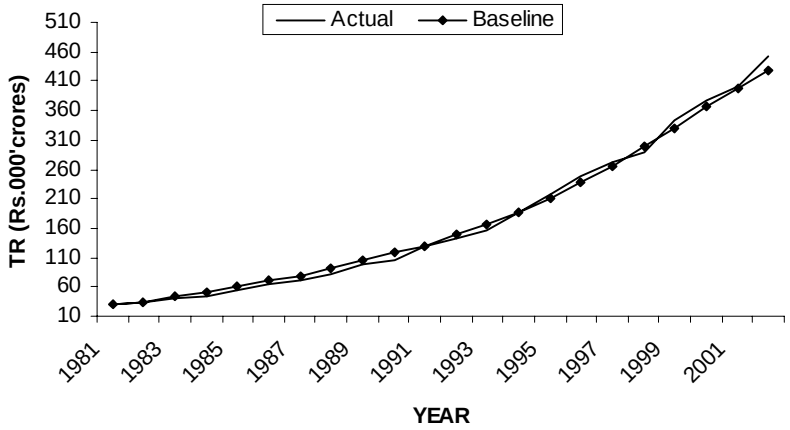


Figure-4: Actual and baseline values of real agricultural output

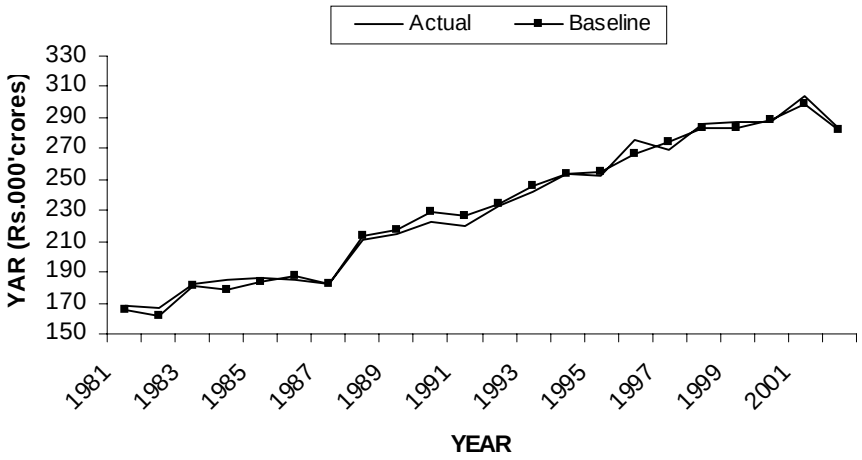


Figure-5: Actual and baseline values of real output in manufacturing

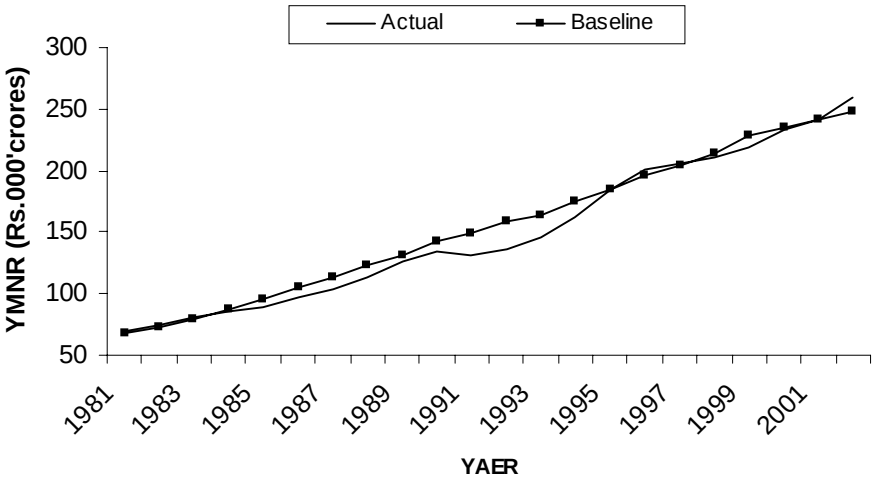


Figure-6: Actual and baleus real output in infrastructure

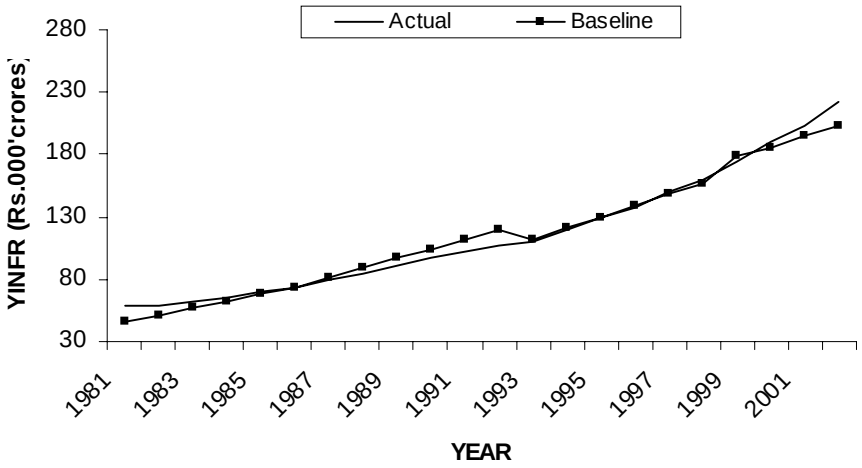


Figure-7: Actual and baseline values of real output in services sector

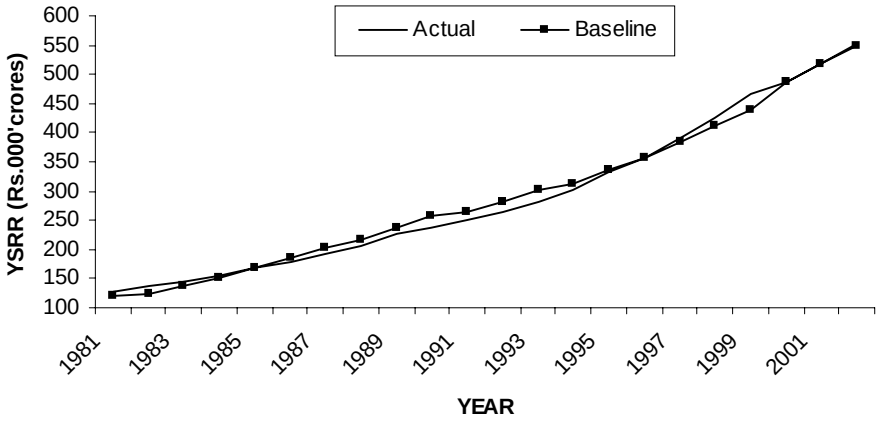


Figure-8: Actual and baseline values of unit value of exports

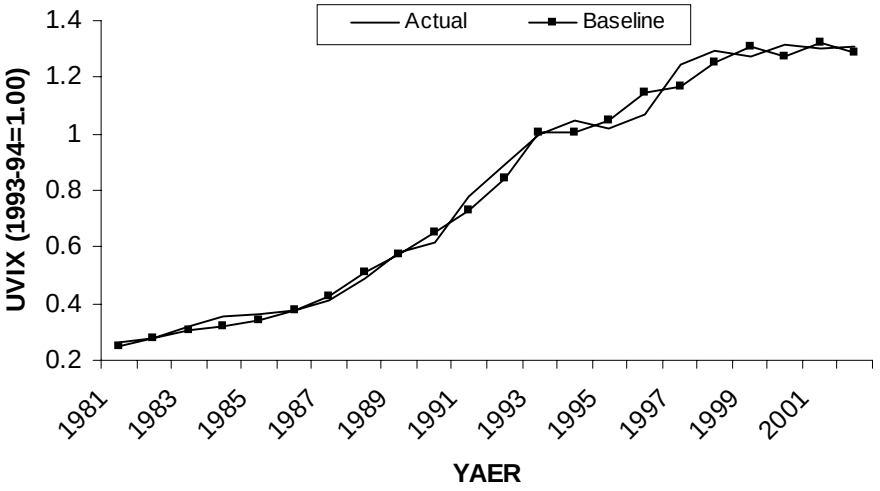


Figure-9: Actual and baseline values of real imports

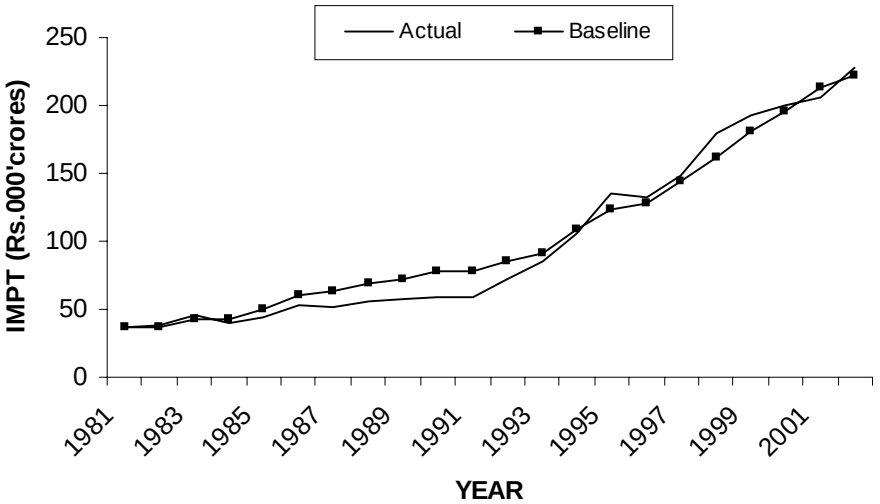


Figure-10: Actual and baseline values of nominal exchange rate

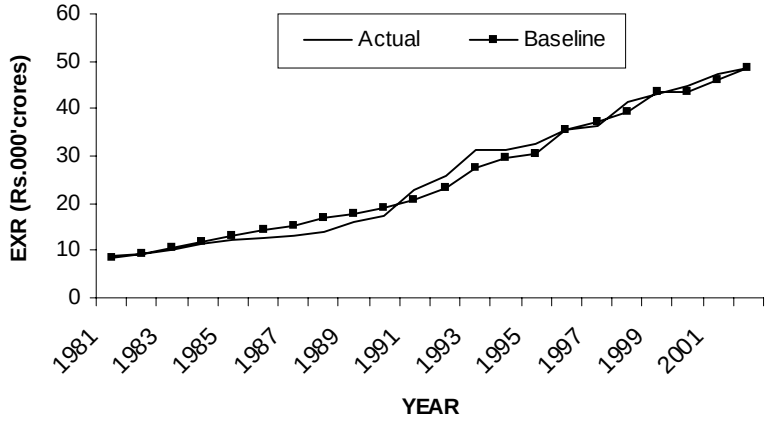


Figure-11: Impact of 10% sustained increase in public investment in infrastructure on real aggregate output

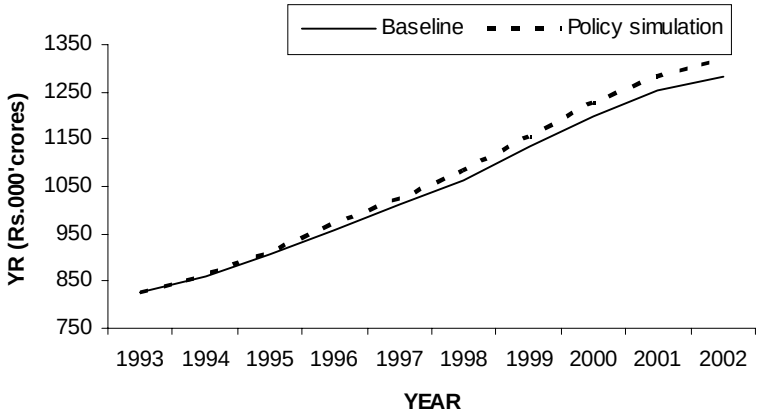


Figure-12: Impact of 10% sustained increase in public investment in infrastructure on private investment in infrastructure

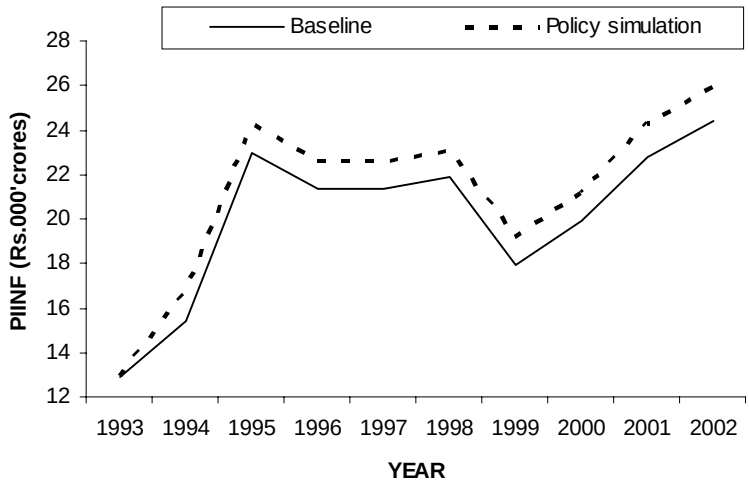


Figure-13: Impact of 10% sustained increase in public investment in infrastructure on price level

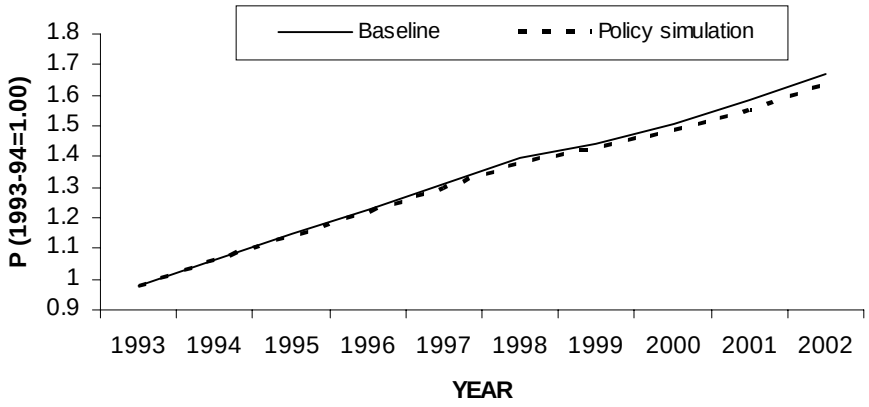


Figure-14: Impact of 10% sustained increase in public investment in infrastructure on real agricultural output

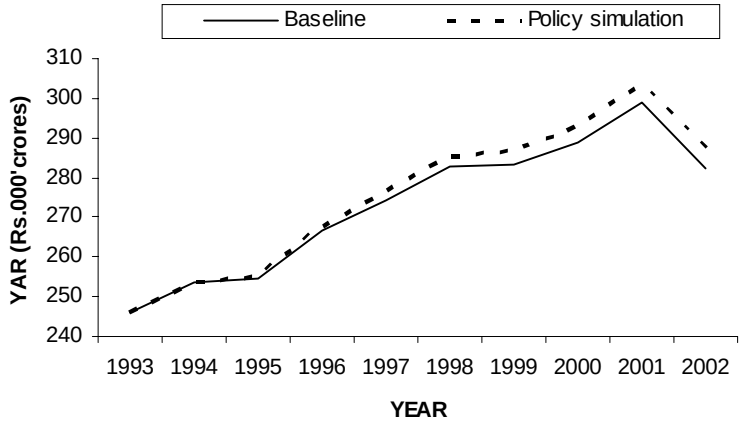


Figure-15: Impact of 10% sustained increase in public investment in infrastructure on real output in infrastructure

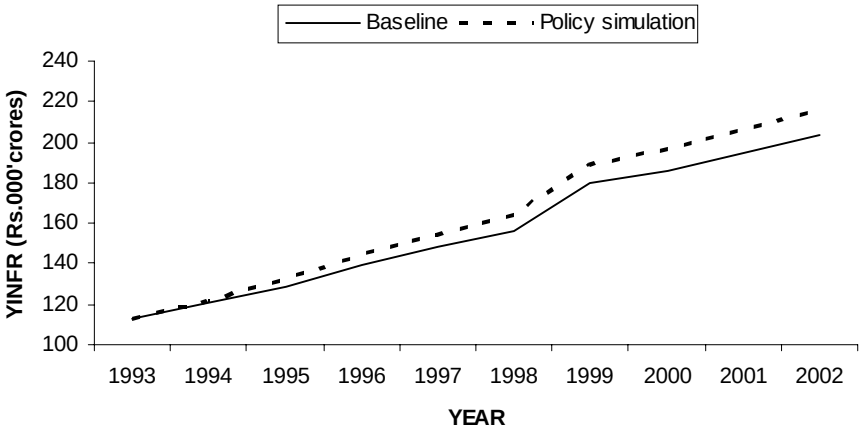


Figure-16: Impact of 10% sustained increase in public investment in infrastructure on real output in manufacturing

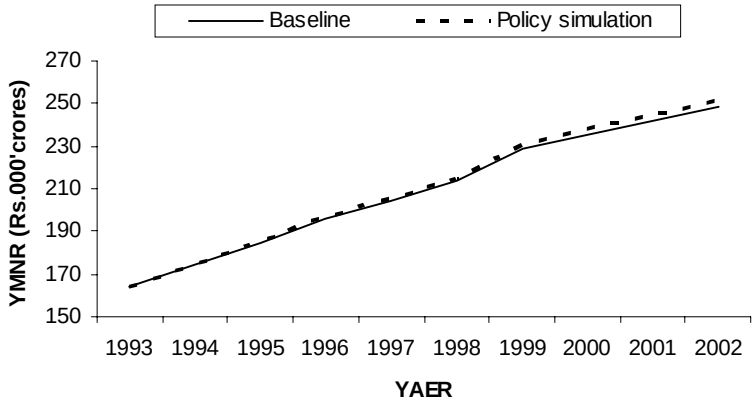


Figure-17: Impact of 10% sustained increase in public investment in infrastructure on real output in services

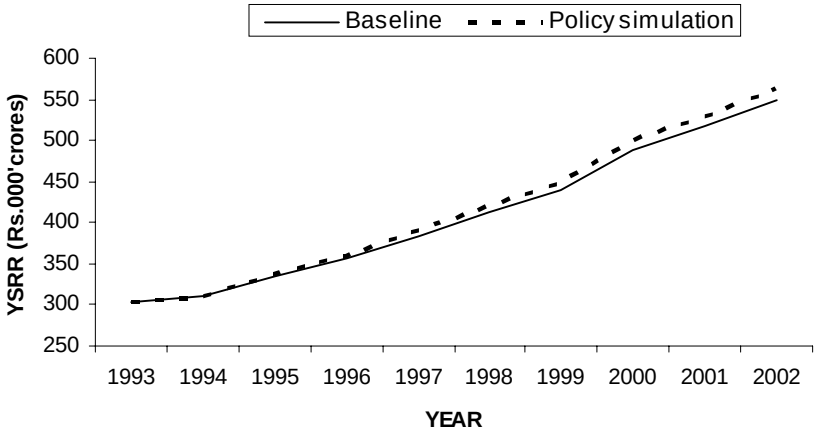


Figure-18: Impact of 10% sustained increase in public investment in infrastructure on real imports