ABSTRACT: This study investigates the influence of public investment on private investment in India, at both the aggregate and Sectoral levels and under two different modes of deficit financing – monetisation and commercial borrowing – in an eclectic macroeconometric modelling framework. Using Generalised Method of Moments (GMM), the two simulation exercises conducted in the study highlight the crowding-in effect of public investment on aggregate private investment, irrespective of the mode of financing. The favourable accelerator effect and the complementary effect are found to outweigh the deleterious interest effect in both simulation exercises. At the Sectoral level, public investment is found to most strongly and positively affect private investment in manufacturing, followed by agriculture, the service sector, and finally infrastructure. The impact of public investment on the other sectors included in the model accords well with theoretical expectations.

KEY WORDS: Public investment, Private investment, crowding in, crowding out, India.

JEL CLASSIFICATION: C15, C51, E22.
1. INTRODUCTION

The importance of investment in enhancing and sustaining an economy’s growth performance cannot be disputed. Economists agree on its positive role in expanding the capital base and other resources essential for developing an economy’s growth, employment level, and competitiveness. To increase the investment structure, economies turn to the government or private sector (both domestic and external), or to a combination of both, depending on the nature of the economy.\(^1\) The research community has observed the behaviour of private investment in various economies across the globe when certain alterations are attempted in the public investment component.\(^2\)

The existing literature provides three theories of the possible linkage between public and private investment. Neo-classical theory advocates the substitutability hypothesis, according to which an increase in public investment will lead to a crowding out of private investment. Any increase in public sector expenditure will need to be financed out of the given stock of funds available in the economy and hence competition between the private and public sectors for the available funds causes the interest rate to rise. The higher interest rate ultimately adversely affects the interest-sensitive components of private investment. Keynesian economics advocates a complementarity hypothesis in which there is a direct association between public and private investment; i.e., any increase in public investment creates a favourable environment for private investment by providing better infrastructure, enhancing productivity, and increasing profitability.\(^3\) The public sector’s crowding-in effect can also be explained by public sector contracts with the private sector. Finally, the Ricardian Equivalence Hypothesis (Barro, 1989) posits that the relationship between the two investment choices is neutral.

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\(^1\) In capitalist countries most investment comes from the private sector, with a very limited contribution by the public sector. On the contrary, in developing and communist countries (India, China, Russia) the public sector is the major investor in the economy.

\(^2\) Scholars have been interested in examining the relative impact of public and private investment on an economy’s growth performance (Khan and Reinhart 1990). If they have a different effect on growth it is important to elucidate the linkages between them so that proper policy stances can be devised (Cavallo and Daude 2010).

\(^3\) Any increase in public investment in infrastructure projects like roads, sewage systems, harbours, energy, etc. improves the productivity of private investment and reduces production costs in the private sector, thereby enhancing its profitability. Thus, public investment ‘crowds in’ private investment.
Due to infinite horizons, perfect foresight, and absence of liquidity constraints, rational economic agents will consider present increases in government expenditure or tax cuts (increased fiscal deficit) as future liabilities. Any dissaving by the government is offset by a rise in the savings of rational economic agents, leaving the total national savings unchanged. Their wealth position is unaltered and hence there is no effect on consumer purchases. Since there is no effect on the interest rate, private investment is not affected.

There have been many empirical studies, but the evidence is largely inconclusive and the studies have been primarily conducted in a single equation framework and do not consider the sources of public spending financing. The present paper examines the nature of the relationship between public and private investment in the case of India, which is an interesting candidate owing to its frequent policy changes, occasional public sector stimulation packages, and efforts to increase private participation in the economy through economic liberalisation. The study analyses the public–private investment linkages in a macroeconometric modelling framework by taking into account the other endogenously determined sectors of the economy. It highlights the possible influence of public investment on private investment at both the aggregate and sectoral level and under two different financing modes, monetisation and commercial borrowing. The Generalized Method of Moments (GMM) is applied to estimate the structural model.

Using data for the period 1981–82 to 2015–16, the two simulation exercises report public investment’s crowding-in effect on India’s aggregate private investment, financed by either monetisation or borrowing from commercial banks. In both cases the favourable accelerator effect and the complementary effect on private investment outweigh the deleterious interest effect in a macro-modelling framework. At the sectoral level, public investment is found to affect private investment in manufacturing most strongly and positively, followed by investment in agriculture, the service sector, and finally infrastructure. The impact of public investment under the two different financing modes on the other sectors included in the macro model accords well with theoretical expectations.

The rest of the paper is organised as follows. Section 2 provides a heuristic overview of the existing literature. Section 3 outlines the analytical framework of
the developed macro model along with its characteristic features. Section 4 discusses the data, the model estimation, and its predictive accuracy. The results of policy simulations are presented in section 5 and section 6 concludes.

2. LITERATURE REVIEW

The impact of public investment on the private investment in an economy has been the topic of recurrent discussions, along both theoretical and empirical lines. Not only is there a lack of theoretical unanimity but the research fraternity has also failed to find any conclusive empirical evidence. Scholars started by examining the influence of public investment on private sector productivity generally and economic growth particularly. Some studies (Ram and Ramsey, 1989; Aschauer, 1989a; Munnel, 1990; Khan and Kumar, 1997; Heintz, 2010) found that public investment had a substantial productive role in the production technology of the private sector, whereas others, while doing away with the methodological issues of earlier studies (Tatom, 1991; Evans & Karras, 1994; Sturm & de Haan, 1995; Pereira & de Frutos, 1999), found that public investment had a neutral effect on private sector productivity.

In another growing strand of the literature, researchers have attempted to examine the association between private and public investment indirectly by estimating an investment model. These studies can be categorized in two subgroups depending on whether they adhere to the complementarity or substitutability hypothesis. Studies arguing for a positive association (complementarity or crowding in) between public and private investment include the following: Aschauer (1989a); Greene and Villanueva (1991); Erenburg and Wohar (1995); Bahmani-Oskooee (1999); Ahmed and Miller (1999); Ramirez (2000); Pereira (2001); Voss (2002); Narayanan (2005); Erden and Holcombe (2005); Alani (2006); Dreger and Reimers (2016); Abaid and Fuceris (2016). By contrast, a number of studies favour substitutability between the two variables (Baily, 1971; Barro, 1981; Knot & de Haan, 1999; Looney, 1995; Apergis, 2000; Dong, 2006; Afnos & St Aubyn, 2009; Hussain et al., 2009; Cavallo & Daude, 2011; Xu & Yan, 2014). However, the results are sensitive to the type of economy investigated, the analytical framework and econometric method adopted, the

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4 A number of studies have also reported evidence of neutrality between the two (Liu & Ma 2001; Raju & Mukherjee 2010; Hur et al. 2014).
transmission channel, the level of segregation used for analysis, the time period, the source and kind of public expenditure, and the development level and institutional quality of the examined country.

In the Indian context, researchers have also shown an increasing interest in uncovering the impact of public investment on private investment. Initially, scholars (Sundararajan & Thakur 1980; Krishnamurty 1985; Serven 1996) examined the nature of the nexus between the two variables and found that private investment was crowded out by public investment, which later was considered a growth-retarding factor. An interesting study by Pradhan et al. (1990) examines the impact of public investment on private investment in India taking into account the sources of public investment financing and its allocation under various scenarios. Using a computational general equilibrium model (CGE) and assuming the non-neutrality of money, the authors find that private investment is crowded out as a result of public investment hikes. However, the authors support the desirability of initial crowding out owing to its favourable effect on total investment and income distribution. Applying the SVAR method, Mitra (2006) finds substitutability in the short run & complementarity in the long run. Using an asymmetric VAR method, Chakraborty (2007) reports the absence of any real crowding out between the two variables: instead the two are found to be positively correlated. In another case, Raju and Mukherjee (2010) document evidence for the neutrality hypothesis. Sahu and Panda (2012) find evidence in favour of the crowding-out hypothesis in the long run, although GDP has a positive effect on private investment. Using the autoregressive distributed lag model (ARDL), Mohanty (2016) finds the crowding out of private investment as a result of increasing fiscal deficits in both the short and long run. Muthu (2017) reports the crowding in of private investment due to an increase in total public investment in both the short and the long run. After segregating public investment into its infrastructural and non-infrastructural investment components, the former is not found to have any impact on private investment whereas the latter affects it favourably.

Though a plethora of studies have been conducted in both developed and developing countries with both uniform and mixed panels, the results are largely divergent and the adopted methodologies mostly lack the desirable features. This study examines the impact of public investment on private investment in India.
The paper contributes to the existing literature in the following ways. Firstly, we develop an eclectic macroeconomic model to examine the nexus between the two variables in a framework that includes both the supply and demand sides of various sectors of the economy. Secondly, the study examines the likely response of private investment to public investment under two different modes of public investment financing. In addition to the aggregate analysis, the study evaluates the nature of the relationship at the sectoral level and analyses the response of private agricultural, manufacturing, infrastructure, and service sector investment to changes in public investment. Finally, the study highlights the impact of public investment on the model’s other endogenous variables.

3. ANALYTICAL FRAMEWORK

The model adopted to conduct the empirical exercise is theoretically eclectic in nature and primarily belongs to Tinbergen–Klein–Goldberger tradition. The causal structure of the model is simultaneous in nature, developed particularly for policy simulation. While most of the early models tend to rely on either the Keynesian or the classical paradigm, in many developing countries like India, supply side constraints are a major problem (Khan & ud Din, 2011). We specify the production functions, investment functions, and price functions for the agriculture, manufacturing, services, and infrastructure sectors separately (Bhattacharya and Kar, 2005) in order to gain a comprehensive insight into supply side factors and heterogeneous dynamics in terms of production, price, and investment behaviour.

Our model strives to balance classical and Keynesian approaches regarding the effectiveness of money supply on prices and output. It considers both price and income transmission channels of fiscal impulses to the external sector, which are comprehensively discussed in the theoretical literature (Rangarajan & Mohanty, 1997). Fiscal deficit is assumed to increase the aggregate absorption level in the economy immediately, relative to output, as capital stock responds with some lag. Thus, imports may grow as a consequence of both. The price channel, on the other hand, depends on how the fiscal deficit is financed.

The simplicity of the model is a deliberate attempt to make black box causal effect relationships transparent – as happens in large-scale macro models – in order to more easily show policymakers how policy shocks/exogenous variables affect the
outcome variables in the economy. The model’s flexible and adaptable nature provides an interesting way to change instruments and target variables in order to answer different policy questions. If necessary, the sub-components of the model can easily be expanded, and thus the basic nature of the model is a ‘work in progress’. The model is applied to track the overall macro-economic ramifications of fiscal deficit. Finally, the specific equations are a sub-set of those from several tested regression specifications that have higher goodness of fit, the appropriate theoretical sign, and significance of parameters.5

4. MODEL ESTIMATION AND PERFORMANCE

The complete model consists of four major blocks: real sector, fiscal sector, monetary sector, and external sector. It contains 56 equations (31 behavioural equations and 25 identities) and 82 variables, including dummy variables. A description of the variables used in the analysis is provided in Appendix 2. The model is estimated using annual data for the period 1981–82 to 2015–16. The model is estimated equation-by-equation using the Generalized Method of Moments (GMM).6 All equations are estimated in conformity with the underlying economic theories. The dummy variables take care of structural shifts and unusual fluctuations in the data for certain variables. AR terms are used to correct for autocorrelation. Appendix 1 provides the estimates of the behavioural equations along with the regression statistics.

To test the empirical accuracy of the full model when describing the historical data and policy analysis, we carry out two sets of simulation exercises using the EViews software package. The first validates the predictive accuracy of the model and the second delineates the model’s policy simulation potential.

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5 The complete structure of the model related to various blocks, equations, & identities has not been reported here to save space. However, the same can be provided on request.
6 All the variables except the various rates used are transformed into natural logarithms. GMM is considered to be superior to the alternatives in handling many econometric problems, including endogeneity, heteroskedasticity, and serial correlation. The number of instruments in each equation is greater than the number of parameters to be estimated; hence, all the equations are over-identified and GMM gives unique estimates of parameters in the over-identified equations (Akbar and Jamil 2012).
The model is assessed for both within-sample and out-of-sample predictive performance. Conventional simulation error statistics such as root mean square percentage error (RMSPE), mean percentage error (MAP), and Theil’s inequality coefficient (U) are used to evaluate the within-sample performance of the model, while stochastic simulations are used to test the out-of-sample performance. The model is solved by running the deterministic simulations in both static and dynamic frameworks for the period 1981–82 to 2015–16. The fundamental difference between the two solution options is that in the case of a static framework, actual lagged values are used in place of lagged forecast values (Pierse, 2001). The root mean square percentage error (RMSPE), mean percentage error (MPE), and Theil’s inequality coefficient (U) of both solution exercises for key variables are reported in Table 1. For almost all variables, under both the static and dynamic solutions, simulation error statistics are within a reasonable range. The trajectories of the static and dynamic simulations along with the actual values of the key variables capture most of the turning points reasonably well. To assess the out-of-sample predictive performance we apply the stochastic simulations that add random shocks to each equation during the forecast simulation.7

Table 1: Simulation error statistics for key variables

<table>
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<tr>
<th>Variable</th>
<th>Static Simulations</th>
<th>Dynamic Simulations</th>
</tr>
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<tr>
<td></td>
<td>MPE</td>
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<td>YAR</td>
<td>0.00</td>
<td>0.024</td>
</tr>
<tr>
<td>YMNR</td>
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<td>YSRR</td>
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<tr>
<td>YINFR</td>
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<td>0.043</td>
</tr>
<tr>
<td>YR</td>
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<td>0.050</td>
</tr>
<tr>
<td>PIAGR</td>
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<td>0.092</td>
</tr>
<tr>
<td>PIMNR</td>
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</tr>
<tr>
<td>PISRR</td>
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<td>0.111</td>
</tr>
<tr>
<td>PIINFR</td>
<td>−0.01</td>
<td>0.170</td>
</tr>
<tr>
<td>PITOTR</td>
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<td>0.092</td>
</tr>
<tr>
<td>PRAG</td>
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<td>0.061</td>
</tr>
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</table>

7 The figures portraying the model’s forecasting performance are not reported here to save space.
<table>
<thead>
<tr>
<th>Variable</th>
<th>Value1</th>
<th>Value2</th>
<th>Value3</th>
<th>Value4</th>
<th>Value5</th>
<th>Value6</th>
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<td>0.02</td>
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<tr>
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<td>0.10</td>
<td>0.07</td>
</tr>
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<td>0.017</td>
<td>-0.03</td>
<td>0.05</td>
<td>0.02</td>
</tr>
<tr>
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<td>0.020</td>
<td>-0.02</td>
<td>0.05</td>
<td>0.02</td>
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<td>0.04</td>
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<td>0.05</td>
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<td>0.00</td>
<td>0.06</td>
<td>0.02</td>
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<td>0.00</td>
<td>0.02</td>
<td>0.01</td>
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<td>CONS</td>
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<td>0.017</td>
<td>-0.01</td>
<td>0.05</td>
<td>0.03</td>
</tr>
<tr>
<td>PCR</td>
<td>-0.02</td>
<td>0.049</td>
<td>0.018</td>
<td>-0.03</td>
<td>0.06</td>
<td>0.02</td>
</tr>
<tr>
<td>GFD</td>
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<td>0.220</td>
<td>0.087</td>
<td>0.11</td>
<td>0.26</td>
<td>0.09</td>
</tr>
<tr>
<td>M3</td>
<td>0.00</td>
<td>0.040</td>
<td>0.015</td>
<td>0.01</td>
<td>0.05</td>
<td>0.02</td>
</tr>
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<td>PLR</td>
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<td>0.100</td>
<td>0.047</td>
<td>0.00</td>
<td>0.11</td>
<td>0.06</td>
</tr>
<tr>
<td>EXT</td>
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<td>0.073</td>
<td>-0.31</td>
<td>0.36</td>
<td>0.21</td>
</tr>
<tr>
<td>IMP</td>
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<td>0.23</td>
<td>0.13</td>
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<tr>
<td>NOIMP</td>
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<td>0.051</td>
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<td>0.040</td>
<td>0.01</td>
<td>0.11</td>
<td>0.05</td>
</tr>
<tr>
<td>TB</td>
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<td>0.482</td>
<td>0.216</td>
<td>0.19</td>
<td>0.66</td>
<td>0.11</td>
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<td>CAB</td>
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<td>0.613</td>
<td>0.16</td>
<td>1.93</td>
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<td>EXR</td>
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<td>0.114</td>
<td>0.031</td>
<td>0.03</td>
<td>0.14</td>
<td>0.05</td>
</tr>
<tr>
<td>KAGR</td>
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<td>0.011</td>
<td>-0.02</td>
<td>0.03</td>
<td>0.02</td>
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<tr>
<td>KMNR</td>
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<td>0.020</td>
<td>-0.08</td>
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<td>0.08</td>
</tr>
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<td>KSRR</td>
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<td>0.022</td>
<td>0.33</td>
<td>0.38</td>
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<tr>
<td>KINFR</td>
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<td>0.020</td>
<td>0.021</td>
<td>0.13</td>
<td>0.16</td>
<td>0.07</td>
</tr>
</tbody>
</table>
5. RESULTS AND DISCUSSION

The prime concern of the study is to explore the impact of public investment on private investment in India by taking into consideration the modes of public investment financing. The study also highlights the potential effect of public investment on the system’s other endogenously determined macroeconomic sectors. To this end, by incorporating the above designed model we conducted the following policy simulations:

Simulation 1: Sustained 40% increase in real public investment (10% increase in agriculture, 10% increase in manufacturing, 10% increase in services, and 10% increase in infrastructure) financed by money creation.

Simulation 2: Sustained 40% increase in real public investment (10% increase in agriculture, 10% increase in manufacturing, 10% increase in services, and 10% increase in infrastructure) financed through borrowing from commercial banks.

1.1. Public investment financed through money supply

We start with a dynamic deterministic solution of the model in order to obtain the coefficients of the endogenous variables, popularly called in the literature ‘control’ or ‘base-line’ solutions. Subsequently, policy solutions are obtained through a persistent (exogenous) shock to policy variables by running a dynamic deterministic path under the assumption of ceteris paribus. The divergence so obtained between the base line and policy solutions is ascribed to the policy changes under examination.

Table 2: Simulation Scheme 1

<table>
<thead>
<tr>
<th></th>
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<th></th>
<th></th>
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</thead>
<tbody>
<tr>
<td>YAR</td>
<td>0.15</td>
<td>0.17</td>
<td>0.53</td>
</tr>
<tr>
<td>YMNR</td>
<td>1.76</td>
<td>1.81</td>
<td>4.09</td>
</tr>
<tr>
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<td>1.46</td>
<td>1.47</td>
<td>3.94</td>
</tr>
<tr>
<td>YINFR</td>
<td>4.32</td>
<td>5.24</td>
<td>8.65</td>
</tr>
<tr>
<td>YR</td>
<td>1.58</td>
<td>1.67</td>
<td>6.18</td>
</tr>
</tbody>
</table>
Y    6.10    6.20    5.52
PIAGR 2.59    3.04    13.20
PIMNR 8.19    8.39    20.50
PISRR 2.30    2.26    7.21
PIINFR 4.65    4.73    4.96
PITOTR 4.47    4.57    14.95
PRAG –3.40    –3.51    –4.25
PRMN 3.74    3.97    4.02
PRSR 10.86   11.10    11.41
PRINF 4.65    4.73    4.96
PGDP 5.61    5.75    5.79
P  5.71    5.80    5.85
GXP 4.62    4.48    10.70
GFD 10.33    9.53    12.95
M3 26.06    29.98    93.57
PLR –0.35    –0.44    –0.52
EXT 0.53    0.67    8.47
IMP 1.44    1.54    9.67
UVEXP 6.87    7.03    8.10
TB* 2.74    2.78    11.39
CAB* 7.04    7.14    29.30
EXR** 2.16    2.19    2.25
KAGR 1.23    1.33    4.62
KMNR 3.75    4.45    6.57
KSRR 1.05    1.14    7.72
KINFR 3.89    4.52    6.99

**NOTE:** # = {{(PS-BS)/BS}*100. Where PS is defined as policy-simulated data and BS as base-line-simulated data. *(+)* indicates deficit and (~) indicates surplus. **(+)** means depreciation of domestic currency and (~) denotes appreciation.

Table 2 reports the effects of increased public investment financed through the monetary route on the various endogenous variables in Simulation 1. At the outset it should be noted that public investment, treated as an exogenous variable
in the model specification, is supposed to have twin effects. First, according to multiplier principle, increased public investment leads to a lagged output expansion by enhancing the capital base of the economy. Second, competition between public and private investment is supposed to exist. Following a rise in public investment, fiscal deficit and money supply responded positively in the year of shock itself with respective magnitudes of 10.33% and 26.06%. As a result of enhanced aggregate demand, the price level and real aggregate output initially increased by 5.61% and 1.58% respectively. Due to the direct association between money supply and non-agricultural price deflators, the latter is found to increase as a result of an increase in the former. The general price level in the economy as measured by WPI also showed an increasing tendency of about 5.71% following the rising trends of the aggregate deflators. The increased price level in the economy resulted in currency depreciation and a hike in the unit value of the export index of 2.16 and 6.87 percentage points respectively. Owing to the increased money supply the interest rate responded as per the theoretical relationship between the two and declined by about 0.35%.

Taking into account the direct impact of public investment on private investment, it can be observed from Table 2 that the two variables are positively related (complementary) and therefore the former crowds in the latter in the first year of the policy change. Table 2 reveals that public investment increases private investment in the immediate period by about 4.47% with a public investment multiplier equal to 1.30 (shown in Table 4 below). However, according to the macroeconomic model adopted in the study it is appropriate to entertain the influence of other variables supposed to influence the level of private investment in the economy. Thus, to provide a more lucid evaluation of the public–private investment nexus in India the study examines both the complementarity channel and the interest rate channel. On the whole, it can be observed that public investment has a favourable impact on private investment when the former is financed through monetisation because all the effects – complementary,

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8 Increased public investment through monetisation increases the money stock in the economy, and therefore the interest rate changes accordingly. It is imperative to take cognizance of the interest effect on private investment as well, since the former is supposed to be an important determinant of the latter.
accelerator, and interest rate – move in the desired direction of enhancing private investment in the immediate period.

On the external side of the economy, Table 2 reveals the problem of trade and current account deficits of 2.74% and 7.04% respectively. This result is a clear reflection of the fact that relative currency depreciation and the hike in the unit value of the export index leads to a 1.44% increase in imports and a meagre 0.53% increase in exports. The reason is that part of the expansionary effect of currency depreciation is offset by a rise in the unit value of the export index, and therefore exports rise by a lower magnitude than imports.

In the short run the variables’ response remains more or less similar to that of the immediate period, except that some change in trends is observed due to the persistent nature of the shock. The movement of fiscal deficits and money supply is the same, but the magnitude of the fiscal deficit response decreases to 9.53% and that of money supply increases to 29.98%, relative to their response in the immediate period. Following the transmission analogy observed in the first period, real output continues to increase by a higher magnitude of 1.67% due to continuous additions to the capital stock through consistent doses of public investment. Public investment crowds in private investment at both the sectoral (agriculture, manufacturing, infrastructure, services) and aggregate levels. The price levels follow the upward trajectory, along with exchange rate and the unit value of the export index, whereas the interest rate falls due to the increased money supply in the economy. Imports consistently rise by about 1.54% due to increased import demand following an output expansion, and increase in domestic absorption and exports also rises – but only marginally, by about 0.67%. The existence of a gap between imports and exports leads to continuous trade and current account imbalances.

In the long run a persistent increase in public investment leads to a continuous aggregate output expansion of around 6.18%, and at the sectoral level the infrastructure sector witnesses the maximum hike relative to the other sectors included in the analysis. The value of the long-run output multiplier is 3.78 (Table 4). Fiscal deficits, money supply, price level, exchange rate, and interest rate follow a similar pattern to that observed in the immediate and short-run periods. Total private investment rises consistently by about 14.95% with a cumulative
long-run multiplier equal to 1.94. Thus, the study reveals that if public investment is financed by monetisation a case of strong crowding in is inevitable, since the three effects mentioned earlier are operative during the immediate, short-run, and long-run periods. A similar pattern is observed at the sectoral level, with the manufacturing sector registering the maximum crowding in. Exports rise by about 8.47% and imports by 9.67% due to the already mentioned reasons of increased output, domestic absorption of imports, and currency depreciation for exports. Finally, both trade and current accounts are continuously plagued with undesirable deficit increases of about 11.39% and 29.30% respectively.

5.2. Public investment financed through borrowing from commercial banks

To conduct this simulation exercise, some adjustments in the model specifications are necessary. Reserve bank credit to the government, earlier treated as purely exogenous, now needs to be transformed into an endogenous variable. In this policy scenario, reserve bank credit to the government is expressed as the residual capital needed to balance the gap between fiscal deficit and borrowing from all sources, inclusive of commercial bank credit to the government. In this framework both the exogenous variables like public investment and commercial bank credit to the government are enhanced by the same percentage, and therefore reserve bank credit to the government decreases, leading to a fall in reserve money, and finally in money supply. The reduced money supply in the second simulation initiates various other changes in the economy, as reported in Table 3.

Like in the case of the first simulation, fiscal deficit increases by about 14.40% following an increase in public investment in the first year. But unlike the first case, here the money supply decreases by about 12.66%, leading to an interest rate rise of about 0.47%, a fall in the overall price level of 2.25%, a fall in the exchange rate of about 3.77%, and a fall in the unit value of the export index of 2.67%. Real aggregate output increases by around 0.92% due to the increase in aggregate demand following increased public investment. At the sectoral level a similar response is observed; however, the maximum response is in the infrastructure sector. The variable of prime concern, private investment, responds positively to the increase in public investment, validating the complementarity between the two variables. With a view to incorporating the influence of the accelerator and the interest rate effects, it is observed that the complementary and accelerator
effect of private investment outweighs the adverse impact of increased interest rate on private investment. Therefore, private investment increases even when public investment is financed through commercial bank borrowing in the immediate period.

**Table 3: Simulation Scheme 2**

<table>
<thead>
<tr>
<th></th>
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</thead>
<tbody>
<tr>
<td>YAR</td>
<td>0.07</td>
<td>0.09</td>
<td>0.47</td>
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<tr>
<td>YMNR</td>
<td>1.58</td>
<td>1.59</td>
<td>3.90</td>
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<tr>
<td>YSRR</td>
<td>0.21</td>
<td>0.24</td>
<td>3.30</td>
</tr>
<tr>
<td>YINFR</td>
<td>4.73</td>
<td>5.59</td>
<td>8.59</td>
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<tr>
<td>YR</td>
<td>0.92</td>
<td>0.99</td>
<td>5.48</td>
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<tr>
<td>Y</td>
<td>0.54</td>
<td>0.22</td>
<td>1.36</td>
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<tr>
<td>PIAGR</td>
<td>2.56</td>
<td>2.96</td>
<td>12.82</td>
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<tr>
<td>PIMNR</td>
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<td>5.54</td>
<td>17.62</td>
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<tr>
<td>PISRR</td>
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<td>0.52</td>
<td>5.16</td>
</tr>
<tr>
<td>PIINFR</td>
<td>5.47</td>
<td>5.85</td>
<td>7.70</td>
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<tr>
<td>PITOTR</td>
<td>2.52</td>
<td>2.59</td>
<td>12.52</td>
</tr>
<tr>
<td>PRAG</td>
<td>0.14</td>
<td>–0.05</td>
<td>1.87</td>
</tr>
<tr>
<td>PRMN</td>
<td>–1.72</td>
<td>–1.56</td>
<td>–4.93</td>
</tr>
<tr>
<td>PRSR</td>
<td>–1.92</td>
<td>–1.30</td>
<td>–7.56</td>
</tr>
<tr>
<td>PRINF</td>
<td>–2.72</td>
<td>–2.55</td>
<td>–5.88</td>
</tr>
<tr>
<td>PGDP</td>
<td>–1.62</td>
<td>–1.32</td>
<td>–4.93</td>
</tr>
<tr>
<td>P</td>
<td>–2.25</td>
<td>–1.95</td>
<td>–4.80</td>
</tr>
<tr>
<td>GXP</td>
<td>4.95</td>
<td>4.78</td>
<td>10.81</td>
</tr>
<tr>
<td>GFD</td>
<td>14.40</td>
<td>13.78</td>
<td>20.53</td>
</tr>
<tr>
<td>M3</td>
<td>–12.66</td>
<td>–12.43</td>
<td>–43.44</td>
</tr>
<tr>
<td>PLR</td>
<td>0.47</td>
<td>0.51</td>
<td>0.71</td>
</tr>
<tr>
<td>EXT</td>
<td>9.51</td>
<td>10.84</td>
<td>40.96</td>
</tr>
<tr>
<td>IMP</td>
<td>5.93</td>
<td>4.99</td>
<td>27.37</td>
</tr>
</tbody>
</table>
UVEXP –2.67 –2.32 –6.94
TB* –2.53 –7.69 –15.89
CAB* –6.22 –18.91 –39.08
EXR** –3.77 –3.31 –2.69
KAGR 0.67 0.78 4.17
KMNR 3.58 4.00 5.75
KSRR 0.36 0.63 1.67
KINFR 4.32 4.86 6.94

NOTE: # = {(PS-BS)/BS}*100. PS is defined as policy-simulated data and BS as base-line-simulated data. *(+) indicates the deficit and (–) indicates surplus. ** (+) means depreciation of domestic currency and (–) denotes appreciation.

The increased domestic absorption and output growth increases the demand for imports by 5.93%, and exports register a hike of around 9.51%, mostly due to a decrease in the unit value of the export index. This leads to a surplus in the current and trade accounts of 2.53% and 6.22% respectively. In the short run an almost similar behaviour of endogenous variables is reported.

In the long run the fiscal deficit progressively increases by 20.53% and the money supply decreases by 43.44%. The interest rate also follows the upward trajectory and the price level decreases by –4.80%. Domestic currency appreciates by 2.69% and the unit value of the export index declines by 6.94%. The trade and current account balances continue to improve by 15.89% and 39.08% respectively, due to the relatively more pronounced increase in exports than imports because of a stronger price effect than exchange rate effect.9 Due to increased aggregate demand and real net capital stock following sustained non-agricultural public investment, real aggregate output registers a continuous hike of 5.48% with a long-run cumulative multiplier of 3.02 (Table 4). At the sectoral level the infrastructure sector output appreciated most, followed by manufacturing and services. Aggregate private investment responded positively by a magnitude of 12.52% with a cumulative multiplier equal to 1.60 (Table 4). Here again, of the

9 A fall in the unit value of exports outweighs the currency appreciation, and therefore exports rise by a greater magnitude.
various private investment components the manufacturing sector registered the largest increase, followed by agriculture.

The two simulation exercises highlight the crowding-in effect of public investment financed either through monetisation or borrowing from commercial banks. In a macro-modelling framework, the favourable accelerator effect and complementary effect on private investment outweigh the deleterious interest effect in both cases. It is important to mention that although the crowding-in effect is reported under both financing modes the response is greater in the case of monetisation, as is reflected by the relative higher values of impact and cumulative multipliers in the case of monetisation than in the case of borrowing.

Table 4: Impact and cumulative multipliers

<table>
<thead>
<tr>
<th>Variable</th>
<th>Simulation 1</th>
<th></th>
<th>Simulation 2</th>
<th></th>
</tr>
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<tbody>
<tr>
<td></td>
<td>Impact effect</td>
<td>Cumulative Multiplier</td>
<td>Impact Effect</td>
<td>Cumulative Multiplier</td>
</tr>
<tr>
<td>PIAGR</td>
<td>0.45</td>
<td>1.61</td>
<td>0.44</td>
<td>1.56</td>
</tr>
<tr>
<td>PIMNR</td>
<td>2.69</td>
<td>4.73</td>
<td>1.82</td>
<td>4.15</td>
</tr>
<tr>
<td>PISRR</td>
<td>1.90</td>
<td>2.33</td>
<td>0.93</td>
<td>0.96</td>
</tr>
<tr>
<td>PIINFR</td>
<td>0.16</td>
<td>1.10</td>
<td>0.15</td>
<td>1.02</td>
</tr>
<tr>
<td>PITOTR</td>
<td>1.30</td>
<td>1.94</td>
<td>0.74</td>
<td>1.60</td>
</tr>
<tr>
<td>YAR</td>
<td>0.63</td>
<td>1.50</td>
<td>0.30</td>
<td>1.34</td>
</tr>
<tr>
<td>YMNR</td>
<td>1.33</td>
<td>2.16</td>
<td>1.19</td>
<td>2.07</td>
</tr>
<tr>
<td>YSRR</td>
<td>0.37</td>
<td>2.17</td>
<td>0.23</td>
<td>1.39</td>
</tr>
<tr>
<td>YINFR</td>
<td>1.62</td>
<td>5.50</td>
<td>1.76</td>
<td>5.39</td>
</tr>
<tr>
<td>YR</td>
<td>2.00</td>
<td>3.78</td>
<td>1.17</td>
<td>3.02</td>
</tr>
</tbody>
</table>

6. CONCLUSION

The paper scrutinizes the possible interactions between public and private investment at both the aggregate and sectoral level and under two different financing modes; i.e., monetisation and commercial borrowing. A structural macro-econometric modelling framework is developed to comprehensively investigate India’s open and highly deregulated economy. The empirical exercise
documents the evidence for complementarity between the two investment options, irrespective of whether the public investment is financed through monetisation or commercial borrowing. However, the association is more pronounced in the former financing mode than in the latter. From the results it can be observed that the favourable accelerator effect and the complementary effect on private investment outweigh the deleterious interest effect in both simulation exercises.

At the sectoral level, private investment in the manufacturing sector is most responsive to public investment, followed by agricultural investment, service sector investment, and infrastructure investment. Finally, the impact of public investment under alternative financing modes on the other variables included in the model accords well with existing theoretical expectations. In terms of policy implications the study recommends a robust expansion of public investment, particularly in the areas where the response of private investment is substantial. However, a mixture of the two sources of public investment financing would be an appropriate policy due to the negatives associated with both modes, like interest rate, inflation, and external account imbalance.

REFERENCES:


APPENDIX 1.

\[
\begin{align*}
\text{LOG(YAR)} &= 6.99 + 0.51 \times \text{LOG(AREA)} + 0.0016 \times \text{RFI} + \text{LOG(KAGR(-1))} \\
&\quad + 0.26 \times \text{LOG(MSP)} + [\text{AR(1) = 0.4}] \\
\text{LOG(YMNR)} &= 2.62 + 0.58 \times \text{LOG(ADD)} + 0.15 \times \text{LOG(KMNR(-1))} - 0.11 \times \text{LOG(DOILP)} \\
&\quad + [\text{AR(1) = 0.3}] \\
\text{LOG(YSRR)} &= 2.01 + 0.22 \times \text{LOG(KSRR(-1))} + 0.58 \times \text{LOG(ADD)} - 0.02 \times \text{DYSRR} \\
&\quad + [\text{AR(1) = 0.58}] \\
\text{LOG(YINFR)} &= -4.94 + 1.26 \times \text{LOG(KINFR(-1))} + [\text{AR(1) = 0.8}] \\
\text{LOG(PIAGR)} &= -8.66 + 0.91 \times \text{LOG(YAR(-1))} + 0.1 \times \text{LOG(PCFAGR)} - 0.34 \times D02 \\
&\quad + 0.45 \times D03 + 0.6 \times \text{LOG(PIAGR(-1))} + [\text{AR(1) = -0.25}] \\
\text{LOG(PIMNR)} &= 0.46 \times \text{LOG(YMNR)} + 0.71 \times \text{LOG(PCFMNR)} - 0.05 \times \text{PLR} + 0.042 \times \text{LOG(OTEXP)} \\
&\quad + 0.06 \times D04 + [\text{AR(1) = -0.89}] \\
\text{LOG(PISRR)} &= 0.77 + 0.86 \times \text{LOG(YSRR)} + 0.09 \times \text{LOG(PCFSRR)} - 0.02 \times \text{PLR} \\
\text{LOG(PIINFR)} &= -0.6 + 0.5 \times \text{LOG(YINFR)} + 0.36 \times \text{LOG(PCFINFR)} - 0.069 \times \text{PLR} + 0.07 \times \text{TREND} \\
\text{PLR} &= 0.39 + 0.19 \times \text{RP} - 0.12 \times \text{LOG(M3)} + 0.66 \times \text{PLR(-1)} + 0.05 \times \text{INFL} \\
\text{LOG(PRAG)} &= 0.46 - 0.27 \times \text{LOG(YAR)} + 0.58 \times \text{LOG(PYDR)} + 0.30 \times \text{LOG(MSP)} \\
&\quad + [\text{AR(1) = 0.94}]
\end{align*}
\]
\[
\begin{align*}
\text{LOG}(\text{PRMN}) &= 1.44 + 0.16 \times \text{LOG}(M3) + 0.06 \times \text{LOG}(\text{PRAG}) + 0.037 \times \text{LOG}(\text{DOILP}) \\
&\quad + 0.11 \times \text{LOG}(\text{UVIMP}) + [\text{AR}(1) = .96] \\
\text{LOG}(\text{PRSR}) &= -0.54 + 0.23 \times \text{LOG}(M3) + 0.48 \times \text{LOG}(\text{PRSR}(-1)) + [\text{AR}(1) = .86] \\
\text{LOG}(\text{PRINF}) &= -0.09 + 0.43 \times \text{LOG}(\text{PRMN}) + 0.59 \times \text{LOG}(\text{PRINF}(-1)) \\
\text{LOG}(\text{DT}) &= -5.06 + 0.54 \times \text{LOG}(\text{YNAR}) + 0.03 \times \text{D06} + 1.94 \times \text{LOG}(P) + [\text{AR}(1) = 0.85] \\
\text{LOG}(\text{INDT}) &= -1.25 + 0.93 \times \text{LOG}(YM) + 0.11 \times \text{D07} + [\text{AR}(1) = 0.75] \\
\text{LOG}(\text{NTR}) &= -3.11 + 0.98 \times \text{LOG}(YM) - 0.033 \times \text{DNTR} \\
\text{LOG}(\text{CONS}) &= -0.4 + 0.28 \times \text{LOG}(YM) - 0.7 \times \text{LOG}(\text{CONS}(-1)) \\
\text{LOG}(\text{PCR}) &= -0.99 + 0.47 \times \text{LOG}(\text{PYDR}) - 0.2 \times \text{LOG}(\text{CONS}) + 0.49 \times \text{LOG}(P) \\
&\quad + 0.25 \times \text{LOG}(\text{PCR}(-1)) \\
\text{LOG}(M3) &= 0.64 + 1.07 \times \text{LOG}(\text{RM}) - 0.036 \times \text{CRR} + [\text{AR}(1) = 0.47] \\
P &= 1.19 + 0.51 \times \text{PGDP} + 0.49 \times P(-1) \\
\text{LOG}(\text{DOILP}) &= -1.61 + 1.36 \times \text{OILPRATIO} + 1.05 \times \text{LOG}(\text{WIOLP}) \\
\text{LOG}(\text{DEPAG}) &= -7.6 + 1.32 \times \text{LOG}(\text{KAGR}(-1)) \\
\text{LOG}(\text{DEPMN}) &= -4.66 + 1.09 \times \text{LOG}(\text{KMNR}(-1)) \\
\text{LOG}(\text{DEPSR}) &= -5.23 + 1.09 \times \text{LOG}(\text{KSRR}(-1))
\end{align*}
\]
\[ \text{LOG(DEPINFR)} = -5.23 + 1.15 \times \text{LOG(KINFR}(-1)) \]

\[ \text{LOG(EXT)} = -1.09 + 0.09 \times \text{WGDP} - 0.17 \times (\text{UVEXP} / \text{EXR}) + 1.1 \times \text{LOG(NOIMP}(-1)) \]

\[ + 0.28 \times \text{DEXP} + [\text{AR}(1) = 0.45] \]

\[ \text{LOG(NOIMP)} = -6.62 + 1.02 \times \text{LOG(ADD)} - 0.006 \times (\text{EXR}) + 0.35 \times \text{LOG(EXT}(-1)) \]

\[ - 0.023 \times \text{LOG(UVIMP)} + 0.23 \times D05 + [\text{AR}(1) = 0.82] \]

\[ \text{LOG(OIMP)} = -5.6 + 0.88 \times \text{LOG(YM)} - 0.87 \times \text{LOG(WIOLP)} + [\text{AR}(1) = 0.84] \]

\[ \text{EXR} = 16.54 + 0.23 \times P - 2.03 \times (\text{CAB} / \text{RBFA}) + 4.9 \times D08 - 1.1 \times \text{DEXR} + [\text{AR}(1) = 0.85] \]

\[ \text{LOG(NCIAB)} = -6.72 + 1.19 \times \text{LOG(Y)} + 0.13 \times \text{WGDP} - 0.75 \times \text{DNCIAB} \]

\[ \text{LOG(UVEXP)} = -0.75 + 1.19 \times \text{LOG(P)} + [\text{AR}(1) = 0.73] \]

\[ \text{ABSP} = \text{PCR} + \text{PIAGR} + \text{PIMNR} + \text{PIINFR} \]

\[ \text{ADD} = \text{ABSP} + \text{CONS} + \text{PCFTOTR} + \text{REXP} - \text{RIMP} \]

\[ \text{AD} = \text{ADD} + \text{RIMP} \]

\[ \text{PYD} = \text{YM} - \text{TR} + \text{TP} \]

\[ \text{PYDR} = \text{PYD} / \text{PGDP} \]

\[ \text{INFL} = ((P - P(-1)) / P) \times 100 \]

\[ \text{KAGR} = \text{KAGR}(-1) + \text{PIAGR} + \text{PCFAGR} - \text{DEPAG} \]

\[ \text{KMNR} = \text{KMNR}(-1) + \text{PIMNR} + \text{PCFMNR} - \text{DEPMN} \]

\[ \text{KINFR} = \text{KINFR}(-1) + \text{PIINFR} + \text{PCFINFR} - \text{DEPINFR} \]
KSRR = KSRR(−1) + PISRR + PCFSRR − DEPSR

PITOTR = PIAGR + PIMNR + PIINFR + PISRR

PCFTOTR = PCFAGR + PCFMNR + PCFINFR + PCFSRR

GXP = CONS + PCFTOTR + TP

TR = DT + INDT + NTR

GFD = GXP − TR

RM = RCG + RBCS + RBFA + GCL + RGCB − RNML

IMP = NOIMP + OIMP

TB = EXT − IMP

PGDP = 0.19 * PRAG + 0.18 * PRMN + 0.44 * PRSR + 0.18 * PRINF

REXP = EXT / UVEXP

RIMP = IMP / UVIMP

YR = YAR + YMNR + YINFR + YSRR

CAB = EXT − IMP + INVSBB

Y = PRAG * YAR + PRMN * YMNR + PRSR * YSRR + PRINF * YINFR

YNAR = YMNR + YINFR + YSRR

RCG = GFD − Δ(BCG) − DNB − EB − MISCRR + RCG(−1)

BCG = ΔBCG + BCG(−1)
APPENDIX 2: LIST OF ACRONYMS USED

ABSP: Real private absorption
DEPAG: Real depreciation in agriculture, forestry and fishing (Industry group 1 of NAS), called ‘agriculture’ for simplicity.
DEPINF: Real depreciation in infrastructure including electricity, gas, and water supply, construction, transport, storage and communication (Industry groups 4, 5, and 7 of NAS), called ‘infrastructure’ for simplicity.
DEPMN: Real depreciation in manufacturing including mining and quarrying (Industry Groups 2 and 3 of NAS), called ‘manufacturing’ for simplicity; DEPSR, Real depreciation in services including all others (Industry groups 6, 8, and 9 of NAS), called ‘services’ for simplicity.
DT: Direct tax revenue.
GXE: Government total expenditure centre and state combined.
CONS: Government final consumption expenditure.
IDT: Indirect tax revenues.
KAGR: Real net capital stock in agriculture.
KINFR: Real net capital stock in infrastructure.
KMNR: Real net capital stock in manufacturing.
KSRR: Real net capital stock in services.
NTX: Non-tax revenue (incl. income from entrepreneurship, property, and miscellaneous current receipts).
PCFTOTR: Real aggregate public investment.
PCFTOTR: Aggregate public investment.
PCR: Real private consumption.
PGDP: GDP deflator (2004–05 = 100).
PGKE: Implicit price deflator for public sector investment.
PIAGR: Real gross private investment in agriculture.
PIINFR: Real gross private investment in infrastructure.
PIMNR: Real gross private investment in manufacturing.
PISRR: Real gross private investment in services.
PITOTR: Real aggregate private investment.
PNA: Price deflator for non-agriculture sector.
PPIE: Implicit price deflator for public sector investment.
PRAG: Price deflator for agriculture.
PRINF: Price deflator for infrastructure.
PRMN: Price deflator for manufacturing.
PRSR: Price deflator for services.
PYD: Personal disposable income.
PYDR: Real personal disposable income.
TR: Government current revenues combined.
Y: Aggregate output at factor cost.
YAR: Real output in agriculture.
YINFR: Real output in infrastructure.
YM: Gross domestic product at market prices.
YMNR: Real output in manufacturing.
YNAR: Real output in non-agriculture sector.
YSRR: Real output in services.
YR: Real output at factor cost
TP: Other transfer payments.
PCFAGR: Real gross public investment in agriculture.
PCFINFR: Real gross public investment in infrastructure.
PCFMNR: Real gross public investment in manufacturing.
PCFSRR: Real gross public investment in services.
RFI: Percentage deviation between actual and normal rainfall.
AD: Real aggregate absorption.
ADD: Real aggregate demand for domestically produced goods.
BCP: Bank credit to commercial sector.
CAB: Current account balance.
EXT: Exports (Merchandise).
EXTR: Real exports.
GFD: Gross fiscal deficit of both central and state government.
IMP: Imports (Merchandise).
IMPR: Real imports.
NOIMP: Non-oil Imports.
OIMP: Oil imports.
DOILP: Domestic oil price index (index of mineral oil in WPI basket (2004-05=100).
OILPRATIO: Domestic oil price index upon world oil price index.
M3: Money supply.
RP: Policy rate, bank rate up to 2000–01 and repo rate after that.
P: Wholesale price index (2004–05 =100).
INFL: Rate of inflation.
PLR: Prime lending rate.
RBFA: Net foreign exchange assets of RBI.
RCG: Reserve bank credit to the government.
RM: Reserve money.
TB: Trade balance.
CAB: Current account balance.
UVEXP: Unit value of exports.
AREA: Index of gross cropped area.
BCG: Commercial bank credit to government.
CRR: Cash reserve ratio.
DNB: Non-market borrowings of both central and state government.
EXR: Exchange rate of Indian rupee against US$ (Nominal, Rs. /$).
EB: External borrowings by the govt.
GCL: Government’s currency liabilities to public.
INVSBL: Invisibles in current account balance.
MSP: Average of minimum support price of fair average quality.
MISCR: Other capital receipts of the govt.
NCIAB: Net capital inflows including net capital account in the balance of payments and errors and omissions.
RBCS: RBI credit to the commercial sector.
UVIMP: Unit value of imports.
WGDP: Index number of world’s GDP (2004–05=100).
WOILP: World oil price index (price of Indian basket of oil imports rupees per ton).
D01: Dummy for post-reform period.
D02: Unusual increase in agriculture investment.
D03: Unusual decrease in agriculture investment.
D04: Irregular dummy for manufacturing (2007–08) for sharp increase.
D05: Dummy crisis, 1 for 2008–09 and 0 for others.
D06: Dummy for 1991–92 for change in structure of direct tax.
D08: Dummy representing a large depreciation of rupee exchange rate in 1992–93, 1 for that and 0 for others.