Did public investment crowd out private investment in India?

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Abstract

Our paper uses the ME (Maximum Entropy) bootstrap method to overcome the econometric constraints of using a short time series after the publication of a new macroeconomic series in India. We use a short time series (quarterly data) of stationary and nonstationary variables between 2011-2016 to confirm the positive role of public infrastructure investment. The significant result has policy implications in terms of the current debate, whether public investment 'crowds-in' rather than 'crowds-out' private corporate investment in India.

JEL Classification: E62, C32, H62

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1. Introduction

Private investment in India has averaged around 25% of GDP during 2004-05 to 2015-16, wherein both corporate and household sectors consistently contributed more than 10%. Public sector contributed an average of 8-8.5% of GDP during the same period.

Successive Economic Surveys in India (for instance, 2012-13, 2013-14, and 2014-15) have highlighted several factors causing the decline in private investment over time. The Economic Survey 2013-14 stressed the severity of challenges in financing private investment. It also argued that high and persistent inflation, along with lower real interest rates, are reducing private savings, thus reducing the supply of funds. Accordingly, the survey urged policy measures aimed at reducing the fiscal burden (through fiscal consolidation), stabilizing inflation, and reduction in resource pre-emption, thereby allowing more financial space for private investment (or reduced 'crowding out').

The Central Statistics Office (CSO) of India introduced a new series of national accounts, with certain revisions in the methodology for estimating Gross Value added (GVA) and Gross Domestic Product (GDP) which provides data at 2011-12 prices.[4] Thus, a limited number of observations available posed challenges to perform meaningful time series analysis.

Our paper, hence, uses the ME (Maximum Entropy) bootstrap method to overcome the econometric constraints of using a short time series after the publication of the new macroeconomic series in India. Our results reinforce the crowding-in properties of public investment in India.

The paper is divided into following sections. Section 2 provides a brief literature review. Section 3 interprets the data and discusses some stylized facts regarding the data on investment in Indian economy. Section 4 explains the methodology and reports our estimated results. Section 5 discusses the implications and concludes.

2. Literature review

In the Indian context, Chakraborty (2007, 2016) attempted to explore both real and financial aspects of the crowding out argument and found no evidence for either. In recent years, Bahal et al. (2015) observed crowding-out effects on private investment during 1950-2012, whereas the opposite results were highlighted for the post-1980 period. Dash (2016) found evidence for crowding-out of private investment for the period 1970-2013, which was subdued during the post-liberalization period a positive impact of public infrastructure investment on private investment in the short run.

Mallick (2016) attributed the crowding-out effects of public investment during 1970-2013 to non-infrastructure government investment. Chhibber and Kalloor (2016) argued for crowding-in effects of public investment on aggregate and sector-wise (corporate and non-corporate) private investment for the period 1980-2014.

[4] http://www.mospi.gov.in/sites/default/files/press_release/nad_press_release_30jan15.pdf

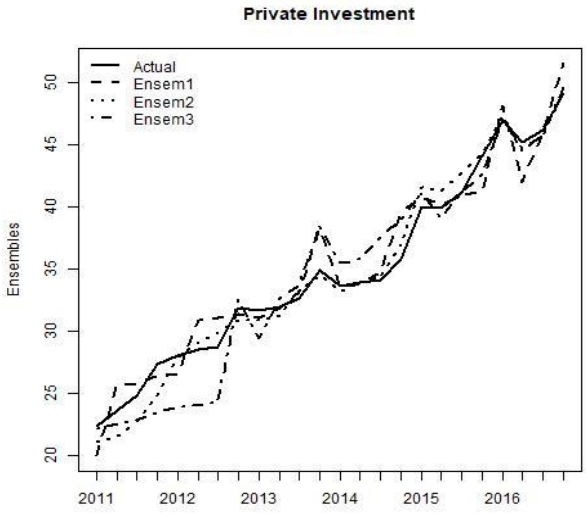
The empirical literature reviewed here relies on Autoregressive Distributed Lag (ARDL) models and Vector Autoregressive (VAR) models. ARDL and VAR models often involve differencing or de-trending of variables to deal with the problems associated with ubiquitous non-stationarity of underlying macroeconomic time series. Moreover, these models often yield insignificant results when the time series is short.

In this paper, we consider maximum entropy bootstrap (meboot) based on Efron (1979) for exploring determinants of private investment in India.

The 'meboot' algorithm is a seven-step procedure which allows one to generate replicates or 'reincarnations' of the original series, as termed by Vinod (2004), to be used for statistical inferences. The meboot resamples allow overcoming the unit root and structural change pretest problems, while avoiding any differencing-type transformations of original time series simply for ensuring the stationarity assumption.[5] In addition, the constructed ensembles have the property of retaining the overall shapes of autocorrelation and partial autocorrelation functions of the original time series data, without imposing parametric constraints.

Figure 1 below shows the actual data on private investment and a sample of three replicas generated from the meboot algorithm. It shows that the basic shape of the non-stationary I(1) series is retained in each replica as the resamples are strongly dependent on it.

Figure 1: Actual and generated ensembles of private investment (in INR billion) used for confidence intervals



3. Interpreting Data and Model Implications

We explore the determinants of private investment following Chakraborty (2007,

[5] For further detailed on the seven step algorithm see Vinod (2009 and 2013).

2016) by incorporating interest rates (both short and long term) in the model equation as below to gauge the impact of interest rates on private corporate investment:[6]

$$I_{pvt} = a + \beta_1 I_{pub} + \beta_2 i_r + \beta_3 C_{pvt} + \beta_4 K_{forgn} + \beta_5 Y_* + e_t \quad (1)$$

where I_{pvt}= private investment, I_{pub}= public investment, i_r= real interest rate (using two versions: short or long term rate), C_{pvt}= credit to the private sector, K_{forgn}= foreign investment capital flows, and Y_*= output gap. Both the price and quantity of credit variables are added in the model to test the McKinnon hypothesis, whether the cost of the credit or quantity matters for private investment.

Investment: we categorized the public investment into infrastructure and non-infrastructure, as suggested in Parker (1995). The sector-wise quarterly data on investment is estimated by maintaining the annual relative shares of private corporate and public investment in each quarter.

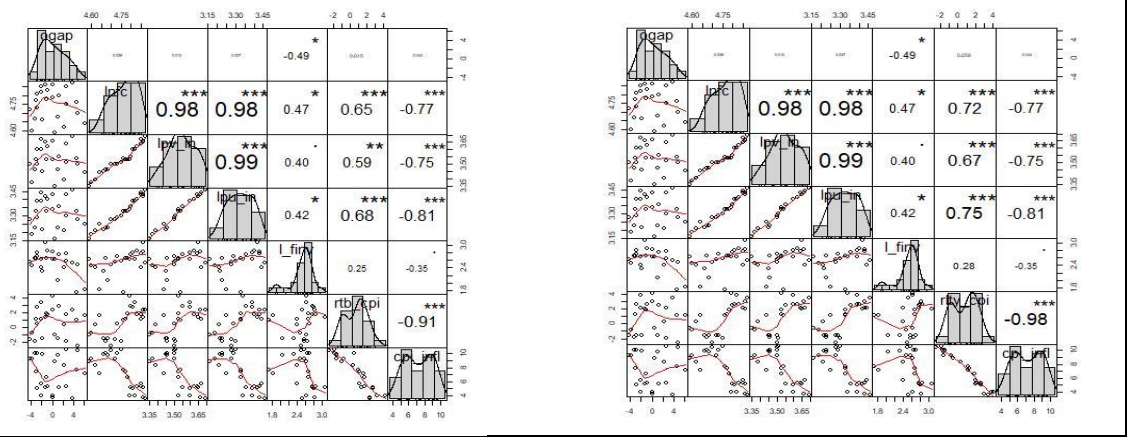
Interest rates: we consider the 91-day treasury bills and the 10-year yield on government securities rate for short and long term interest rates. We used the ex-post real interest rate (backward looking retail inflation adjusted) for our estimation.

Output gap: Many studies have compared the results of the output gap (OG) estimation by using different models in the Indian context. However, despite all the criticisms, this paper estimates potential output using the Hodrick-Prescott filter (HP) filter due to its simplicity.

The simple correlation shown in Figure 2 between private and public investment is very high and positive (even with public infrastructure and non-infrastructure), which signals that public investment may not be crowding-out the private investment during this period. Non-food credit also indicates a similar picture. The direction of causality, however, may be debated as some may argue that the decline in non-food credit is independent of a lack of demand for investment and not vice-versa. Interest rates, whether short or long term highlight a significant positive relationship, suggesting that interest rates matter.

Finally, foreign portfolio capital flows show a low negative relationship with retail inflation dynamics and output gap while a low positive relationship with non-food credit, public and private investment.

Figure 2. Correlation Matrices of the variables



[6] See Chakraborty (2007) for detailed derivation of the equation.

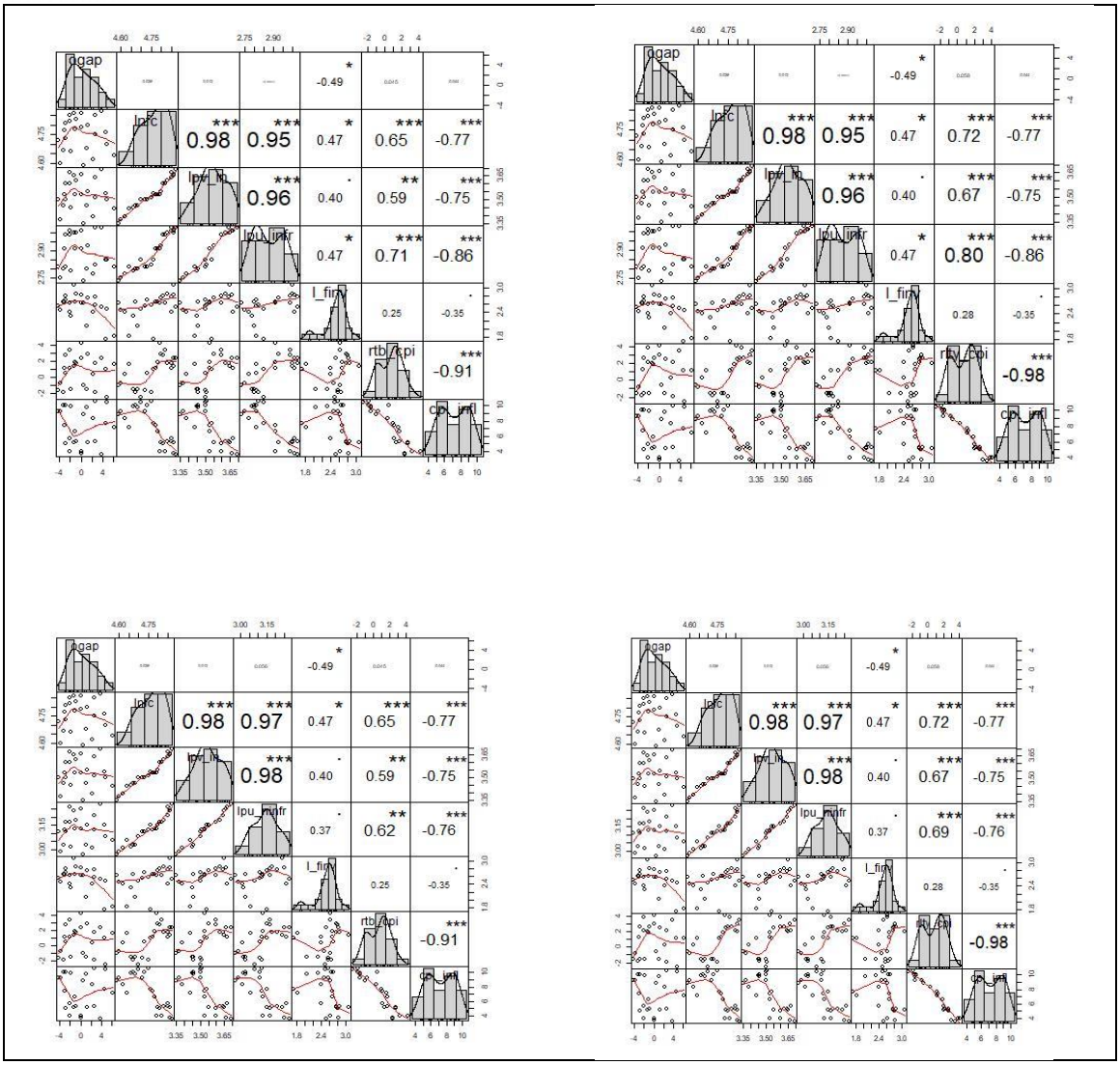


Figure 2: Correlation Matrices of the variables

Notes on Graphs in Figure 2: The distribution of each variable is shown on the diagonal. On the bottom of the diagonal: the bivariate scatter plots with a fitted line are displayed. On the top of the diagonal: the value of the correlation plus the significance level as stars. Each significance level is associated to a symbol: p-values (0, 0.001, 0.01, 0.05, 0.1, 1) have respective symbols ("***","**","*","."," "). "Ogap"=output gap; "lnfc"=log values of non-food credit; "lpv in"=log values of private investment; "lpu in"=log values of public investment; "l finv"=log values of foreign investment; "lpu infr"=log values of public infrastructure investment; "lpu ninfr"=log values of public non-infrastructure investment; "rtb cpi"=cpi-based real treasury bills rate; "rlty cpi"=cpi-based real long-term yield rate; "cpi infl"=cpi-based inflation

4. Estimation and Results

Our specification equation (1) incorporates both fiscal policy and monetary policy instruments relevant for encouraging private investment. We consider three models of fiscal instruments (I_{pub}) as total public investment, public investment in infrastructure, and non-infrastructure separately. We also consider two versions of these three models with monetary policy variable real interest rates (i_r) based on short-run and long-run interest

rates. Since public investment takes time to materialize, our models incorporate regressors for investments made two quarters before the current.

Table 1-2 reports our results for models when our i_r is the short-term and long-term interest rate, respectively. Tables 3 provide the confidence intervals under the 'meboot' procedure for the first model specifications reported in Table 1.
Our confidence intervals continue to support 'crowding-in' of private investment through public investment for the period 2011- 2016. Our findings are, thus, consistent with the recent literature using Indian data, which does not find crowding-out effects of public investment on private investment.

Table 1: Regression Coefficient Estimates Using Short-term Interest Rates

Variable	Model 1	Model 2	Model 3
Real T-Bills rate	-0.008***	-0.008***	-0.004
	(0.001)	(0.001)	(0.002)
Output Gap	-0.002**	-0.001	-0.001
	(0.001)	(0.001)	(0.001)
Foreign Investment	-0.022**	-0.044***	-0.008
	(0.008)	(0.012)	(0.017)
Non-food credit	-0.271*	0.572***	0.559**
	(0.149)	(0.114)	(0.247)
Public Investment	1.084***		
	(0.121)		
Public Investment, Lag2	0.394***		
	(0.100)		
Public Infrastructure Investment		0.351***	
		(0.100)	
Public Infrastructure Investment, Lag2		0.268***	
		(0.093)	
Public Noninfrastructure Investment			0.575***
			(0.184)
Public Noninfrastructure Investment, Lag2			0.004
			(0.167)
Constant	-0.016	-0.846**	-0.910
	(0.252)	(0.303)	(0.527)
Observations	22	22	22
R^2	0.994	0.987	0.972
Adjusted R^2	0.992	0.981	0.961
Akaike information criterion (AIC)	-145.435	-126.616	-110.590
Bayesian information criterion (BIC)	-136.707	-117.888	-101.862
Residual standard error (df=15)	0.007	0.011	0.016

*P < 0.1; **P < 0.05; ***P < 0.01. Figures in parenthesis are t-values.

Table 2: Regression Coefficient Estimates Using Long-term Interest Rates

Variable	Model 1	Model 2	Model 3
Real Long term yield rate	-0.008*** (0.001)	-0.009*** (0.002)	-0.002 (0.003)
Output Gap	-0.002** (0.001)	-0.001 (0.001)	-0.001 (0.002)
Foreign Investment	-0.026** (0.009)	-0.051*** (0.012)	-0.008 (0.019)
Non-food credit	-0.326* (0.184)	0.537*** (0.112)	0.506* (0.265)
Public Investment	1.134*** (0.152)		
Public Investment, Lag2	0.436*** (0.123)		
Public Infrastructure Investment		0.451*** (0.108)	
Public Infrastructure Investment, Lag2		0.265*** (0.091)	
Public Noninfrastructure Investment			0.600*** (0.194)
Public Noninfrastructure Investment, Lag2			0.013 (0.177)
Constant	-0.050 (0.312)	-0.947*** (0.303)	-0.763 (0.591)
Observations	22	22	22
R^2	0.991	0.987	0.969
Adjusted R^2	0.988	0.982	0.957
Akaike information criterion (AIC)	-136.388	-127.497	-108.123
Bayesian information criterion (BIC)	-127.659	-118.769	-99.394
Residual standard error (df=15)	0.009	0.011	0.017

*P < 0.1; **P < 0.05; ***P < 0.01. Figures in parenthesis are t-values.

We find a significantly positive impact of credit cost reductions on corporate investment, albeit of a comparatively smaller magnitude than that of increases in public investment.

The direct crowding-in effects of public infrastructure investment on corporate investment evident in the lagged models (See Model 2 results in Tables 1 and 2) signify the spillover or second-round effects of infrastructure investments on economic activity. The instantaneous effect of public infrastructure investment on corporate investment implies a net reduction in project costs of private investment given the public infrastructure.

A negative coefficient of the output gap indicates a negative impact of macroeconomic uncertainties on private corporate investment. The other finding of the study is that interest rate i.e. cost of credit matters– both short term and long term. However, the magnitude of the impact is smaller than that of the public investment variable.

Table 3: Confidence Intervals for 'Model 1' defined in Table 1

Variable	OLS		Meboot							
			Simple percentile		Boot Percentile		Boot norm		Boot Basic	
	2.5%	97.5%	2.5%	97.5%	2.5%	97.5%	2.5%	97.5%	2.5%	97.5%
Real TBill rate	-.010	0.006	-.016	0.005	-.016	0.005	-.021	0.000	-.021	0.000
Output Gap	-.003	0.000	-.003	0.002	-.003	0.002	-.004	0.001	-.004	0.001
Foreign.Investment	-.039	0.006	-.074	0.006	-.074	0.006	-.056	0.024	-.051	0.028
Non Food Credit	-.588	0.045	-.373	1.284	-.376	1.286	-1.159	0.468	-1.174	0.487
Public Investment	-.826	1.342	-.309	1.220	-.313	1.230	0.725	2.188	0.674	2.216
Public Investment, Lag2	-.181	0.608	-.228	0.925	-.228	0.927	-.422	0.751	-.447	0.709

During our time period, private investment may have galvanized to attain a larger share of resources but did not essentially get crowded-out by the mere presence of public sector investment. The significant but opposite signs of non-food credit indicate that a mere quantity of credit may not be enough for enhancing private investment. The direct intervention of the state through focused infrastructure investment, coupled with the availability of credit, can have a stronger impact on interest rate sensitive private investment. Only by allocating resources for infrastructure, the government encourages private investment.

The negative coefficient of foreign investment (which ideally could be argued to be positive to boost private investment in such equations of investment relations) confirms that the uncertainty towards the stability in the flows of foreign capital had a negative bearing on the scale of private investment.

Our initial correlation boxes indicated a high and positive correlation between the two investments. Since we also want to assess the causal directions, we use an exogeneity test statistic (or unanimity index) suggested by Vinod (2017) to determine the direction and strength of causal and exogenous variables[7].

Causal paths between thirteen variables paired with the private investment are reported in Table 4.

The numbers in the column entitled 'corr.' of Table 10 are Pearson correlation coefficients. Since all p-values are near zero except for the output gap along line 3 of Table 10, all relations in the table have statistically significantly non-zero Pearson correlation coefficients. However, the symmetry of the matrix of Pearson correlation coefficients means that they cannot suggest anything about the underlying causal directions.
When the value in the 'strength' column of Table 10 exceeds 15, the causal direction determination is strong enough to be believed as a preliminary indicator of the true causal direction.

It stands to reason that all variables except LongYld and Ogap along lines 2 and 3 of Table 10 show that long-term yield and output gap influence the private investment(PvtInv), but all other variables are sensitive to independent variation in PvtInv DGP.

[7] See Vinod et.al (2020) for more details on the application.

Table 4: Causal paths between selected variables

cause	response	strength	corr.	p-value
1 PvtInv	RTbill	100	-0.672	0.00032
2 RLYield	PvtInv	31.496	-0.6862	0.00021
3 Ogap	PvtInv	100	0.0118	0.95626
4 PvtInv	PubInv	100	0.9868	0
5 PvtInv	PubInfr	100	0.9595	0
6 PvtInv	PbNnInf	100	0.9733	0
8 PvtInv	RLYield	31.496	0.6745	3e-04
9 PvtInv	FornInv	31.496	0.4027	0.05103
10 PvtInv	CPI	31.496	0.5854	0.00265

5. Conclusion

In this paper, we used a maximum entropy bootstrap (meboot) methodology that allows overcoming the unit root and structural change pretests while ruling out the need for any transformations of original time series.

Our causal path analysis using the R package 'generalCorr' shows that private investment as a data generating process has an independent variation which drives the variation in public infrastructure and non-infrastructure investments, and the variation in long term government bond rates. It highlights the importance of private investment as a driving force for the growth of the Indian economy and difficulties in choosing policies to influence it.

Our meboot results indicate evidence in support of 'crowding in' of private investment through public investment. We find that public infrastructure investment is significant in determining private investment and that a low-interest rate encourages private corporate investment.

Private corporate investment is often cyclical, whereby investment booms are followed by recessions, reflecting among other issues the fact that firm-level capacity utilization or capacity addition are often bulky, expensive, and uncertain. Our time period covers mostly a recessionary phase of the investment cycle following a modest expansion. In the absence of data to cover many business cycles, we capture some aspects of cyclical behavior by including the 'output gap' variable in the model. The public policy implication of our chapter is that the government should remove the infrastructure and bureaucratic bottlenecks in the economy by enhancing 'ease of doing business' in India.

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