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PUBLIC INVESTMENT IN AGRICULTURAL AND GDP GROWTH: ANOTHER LOOK AT THE INTER SECTORAL LINKAGES AND POLICY IMPLICATIONS

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Public Investment in Agricultural and GDP Growth:

Another Look at the Inter-sectoral Linkages and Policy Implications

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Abstract

Despite its reduced share in India's GDP, *agriculture* continues to have a strategic importance in ensuring its overall growth and prosperity. As part of the new economic policy package introduced in the early nineties, there has been a reduction in the rate of public investment. While this may not be bad for the industrial sector, the impact of this policy on agriculture is a matter of concern, in sofar as it not only affects steady growth of agriculture but also influences the overall performance of the economy. This is more so because the agricultural sector public investment has also promoted private investment by way of what is termed as the crowding-in phenomenon. This phenomenon together with *inter-sectoral linkages* is used in this paper to examine the effect of higher public investment for agriculture on the stable growth of this sector as well as of the entire economy. Policy implications of this exercise are important for obvious reasons.

JEL Classification: E22, E23, E27, H54.

Key words: Sectoral linkages, Public Investment, crowding-in

1. Introduction

The share of agriculture in the total GDP has steadily declined to a level of around 15% over the past two decades. This notwithstanding, agriculture continues to play a vital role in the Indian economy. More than 60 per cent of the workforce draws its sustenance from this sector one way or the other. Since a large country like India has to be self sufficient, as far as possible, for its requirements of food and industrial raw materials, the dependence on this sector, is rather vital. Needless to add that at a time when "food security" has become a guidepost for policy makers all over the world, the need for a strong agricultural sector cannot be overemphasized. The related phenomenon of "food inflation" which appears to have gripped all countries adds to the importance with which policy makers need to give agriculture as regards both short run as well as long run policies.

A review of the last 25 years or so need to be recalled here to provide a backdrop to the current exercise as well as to the motivation for undertaking this. What is attempted here is by no means entirely new but all the same worth a revisit in view of the recent developments in India as in most other countries. A fresh emphasis on the policy implications needs to be emphatically highlighted. To start with, one may once again note that performance of the agricultural sector in terms of output growth remains subject to the same fluctuations, if not more than, it had until the late seventies. Needless to say that these are considerably due to year to year and indeed season to season variations in the rainfall. It is not only a matter of how much the total rainfall is but also how this is distributed across space and across different parts of the year. The idea however is that greater investment in agriculture, mostly focused on provision of stable and minimally secure water resources would help us to reduce the effect of weather conditions over time.

Table 1 gives us three year averages of about three decades since the late seventies. We have chosen to look at averages to take care of fluctuations in rainfall as also in policy

perspectives influenced by short run developments as far as possible. Despite this, we see how growth rate fluctuates between nearly 7 per cent in period 4, and over 5 per cent in period 9, to 0.56 in period 3, and 0.41 percent in period 8. The available data also show how real public investment has steadily declined from period 1 to period 7, from about Rs. 105 billion to Rs. 37 billion respectively. For period 8, it stays almost the same with some improvement in period 9 and a major upswing in period 10. We hope that now onwards it stays there. It may also be worthwhile to look at total, i.e., public and private investment in agriculture in relation to GDP for which growth has accelerated since the mid nineties. Here again, we see a steady decline from 2.43 per cent in period 1 to less than 0.6 per cent (one fourth) in period 6. Subsequent periods show some improvement but no way for it to rise back to the original level of 2.43% in period 1, or even to 1.72% in period 2. In period 10, it has merely gone back to the level in period 3. A clear shift in public policy away from public investment in general and in particular in agriculture as a part of the new economic policy regime is quite clear.

Table 1

Pattern of Investment and Growth

(3 year averages)

Serial No.	Period	Real Public Investment in Agriculture (Rs. billion)	Rate of total Investment in Agriculture (Percent)	Annual Rate of Growth in Agricultural Output (Percent)
1	1979-80 to 1981-82	104.96	2.43	1.57
2	1982-83 to 1984-85	97.68	1.72	3.81
3	1985-86 to 1987-88	76.39	1.23	0.56
4	1988-89 to 1990-91	58.07	1.33	6.95
5	1991-92 to 1993-94	45.73	0.88	2.67
6	1994-95 to 1996-97	52.68	0.59	4.65
7	1997-98 to 1999-00	37.15	0.93	2.15
8	2000-01 to 2002-03	42.52	1.31	0.41
9	2003-04 to 2005-06	80.64	1.08	5.08
10	2006-07 to 2007-08	147.19	1.28	3.33

Our concern which motivates the present exercise is that due to its linkages with rest of the economy through supply as well as demand, performance of the agricultural sector is crucial to the overall growth of the economy. We need also to note that prosperity in agriculture is essential to ensure lower levels of poverty and deprivation and regional disparities. Second, as it has earlier been highlighted, public investment is critical because it promotes private investment in agriculture, the so called crowding-in phenomenon. One may even go one step

further to claim that, in many ways private investment, by its very nature, is not a substitute for public investment as far as agriculture is concerned.

2. Issues Under Discussion

With strong demand as well as supply linkages, the performance of industry and agriculture are strongly tied up with each other in a developing country. This has for a long time been a recurrent theme in the literature on economic development (Kuznets, 1955). Many attempts have also been made to quantify their relationship for India in the past[1]. Notable early attempts in this direction were made by Rangarajan (1982), Ahluwalia and Rangarajan (1986), Kumar(1988), Dhawan and Saxena(1992) and Thamarajakshi(1994). A simulation exercise which was carried out by Rangarajan(1982) showed that a one per cent growth in agriculture could generate 0.5 percent growth in industry. The recent years have witnessed a renewed interest in some aspects of agricultural growth and the extent to which it influences the overall GDP growth. Sastry, Singh, Bhattacharya, and Unnikrishnan (2003) showed that agriculture still continues to play an important role in determining the overall growth rate of the Indian economy through its linkages with the other sectors of the economy. It points out that during the sixties, the linkage was mainly through the *production* channel, but during the 1990s the linkage was primarily through the *demand* channel. This aspect was highlighted in Kanwar (2000), Tiffin and Dawson(2003), Chaudhuri and Rao (2004), and Suresh Babu (2005).

It is often claimed that the so called *protectionist and interventionist* rate of growth in India is a matter of history[2], since the overall real GDP has been growing at well over 5 percent since the mid eighties and indeed for most of the years at 6 to 7 per cent per annum[3].

[1] See, Papers presented at the **International Economic Association**, 8th World Congress, New Delhi, 1986.
[2] See, Sinha and Tejani (2004)
[3] Despite the influence of the world economic crisis around, Indian economy could register a whopping growth rate of 8.6% in the January-March quarter of 2010.See, *timesofindia.indiatimes.com* Site visited on

While this is a matter of much satisfaction, it is equally a cause of concern that the overall growth rate has also fluctuated considerably from year to year. To us and to many others, a major reason for this is the *fluctuating performance* of the agricultural sector[4]. This, in turn, may be attributed to variations in the quantum of rainfall over the *agricultural year* (June 1st to May 31st) as also to its distribution over time and space. It seems nevertheless, that this is not the only factor responsible. Though the econometric studies by Krishnamurthy, Pandit and Mahanty (2004) confirm how agricultural sector growth influences overall growth, the question of relationship between agriculture and industry continues to be a much-debated part of the discourse on Indian economy (Chaudhuri and Rao, 2004). Thus, the nature of inter-sectoral linkages and their policy implications remain open to further investigation.

It is useful in the current context to look first at the structure of the economy in terms of shares of the various sectors in the total GDP as well as in the total capital stock. The relevant data are presented in table 2.

July 10, 2010.

[4] Variations in the quantum of rainfall over the agricultural year (June 1st to May 31st) as also its distribution over time and space are important in this context but not sufficient to explain the observed fluctuations.

Table 2

Sectoral Composition of Output and Capital

(5 Year Averages)

Period	Shares of Sectoral GDP			Shares of Sectoral Capital Stock		
	Agriculture	Industry	Services	Agriculture	Industry	Services
1971-75	41.840	16.335	41.646	24.117	20.889	55.001
1976-80	38.560	17.536	43.613	23.518	23.619	52.862
1981-85	36.468	18.371	45.159	22.699	27.433	49.864
1986-90	32.304	19.414	48.281	20.620	32.586	46.793
1991-95	29.578	19.860	50.560	18.219	36.211	45.568
1996-00	25.724	20.349	53.925	15.285	40.334	44.380
2001-05	21.357	19.522	59.109	13.438	41.674	44.887
2006-09	17.092	19.849	62.812	11.452	41.528	47.018

The share of industry in the overall GDP, with a marginal increase over the first one and a half decade, has remained more or less unchanged since the mid-eighties. The major structural shift in the composition of the overall GDP is seen from agriculture to the services sector. A steep fall in the share of the agricultural sector in the total GDP has meant a steep increase in the share of the services sector. While this may be indicative of economic development, the fact that the share of the industrial sector has not shown much improvement is matter of concern. All through the four decades, growth in the Indian economy has been largely service driven. This is not optimal from the long run growth perspective. It may be argued that from a long run standpoint, an economy's growth must be largely driven by industry, supported by agriculture.

A look at the sectoral shares of capital stock reveals certain significant trends. There has been a steep decline in the share of capital stock in agriculture especially since the late nineties. This is clearly the outcome of the decline in public investment in agriculture during the 1990s which in turn has correspondingly reduced private investment in that sector during the same period. The share of capital stock in the services sector has remained more or less constant since the early eighties. Another significant feature is the steep increase in the industrial sector's share of capital stock especially since the late 80s. This is due to the policies and initiatives undertaken since the late eighties to promote industry and further bolstered by the post-1991 economic reforms. However, in spite of the steep increase in the share of industrial capital stock, there has been a decline in the average growth rate in the industrial sector during the late nineties[5]. Could this be linked to the performance of the agricultural sector and, in turn, to the decline in overall investment in agriculture during the 90s, is a question which needs to be examined.

Keeping in mind the issues discussed, we examine how far the growth rates across sectors are generally linked together. In particular, we wish to evaluate how the rate of growth in overall real GDP is influenced by the rate of growth in agriculture. The related important facet of the problem is whether the earlier pattern of linkages persists under the *new policy* regime. Going beyond this numerical part of the exercise, we shall examine the question of stable and adequate growth vis-à-vis the policy regarding public investment in different sectors. An issue that would be relevant in this regard is the *crowding-in* or *crowding-out* impact of public investment on private investment in respective sectors. This would be pertinent to the agricultural sector, in particular.

Proceeding on the above lines, the present exercise goes on to analyze the growth patterns in the various sectors, particularly agriculture and identify the *causes* for the

[5] The average industrial growth declined from about 6.8% during the period 1991-95 to 4.68% during 1996-00.

observed patterns relating these to policies being followed. How far growth in agricultural or total GDP can be promoted by public investment is our primary focus. To ensure that one is not asking for too much, we also treat total government expenditure as endogenous so as to ensure that it is feasible.

2. Data and the Model

Our broad *methodology* is as follows. *First*, a set of relationships is estimated to explain the factors responsible for growth in the *three* sectors namely, agriculture, industry, and services. These are then used to explain rate of growth in the overall GDP. Output for each of the sectors is measured as real *GDP at factor cost* (GDPFC) for the respective sector calculated at 1999-‘00 prices. We adhere to the *CSO classification* of activities under the *three* sectors. Capital is measured as real net fixed capital stock in the respective sectors calculated also at 1999-‘00 prices. Public investment in the agricultural and industrial sectors are measured as real net fixed capital formation by the public sector in agriculture and industry, measured at 1999- 00 prices. Private sector capital formation in agriculture and industry was calculated by subtracting public investment from the total investment into these sectors. Apart from the above variables, for the *agricultural sector* in particular, we have considered *two* other variables, namely, acreage under cultivation, and rainfall for the economy as a whole.

Total net sown area is used as a measure of acreage under cultivation. It is measured in terms of *million hectares*. Official data on net sown area are available up to the year 2005. For the period 2006-‘08, the growth rates of net-sown area are extrapolated by taking the moving average of the previous two periods’ growth rates. The variable rainfall considered is the All-India monsoon rainfall index calculated by the *Indian Institute of Tropical Meteorology*, Pune. Official data on this variable are available up to the year 2000. For the

period 2001-‘08, data on this variable are extrapolated on the basis of available figures, stating the amount of rainfall as a percentage of the Long Period Average (LPA). The Long Period Average (LPA) considered in the study is the average of the All-India monsoon rainfall index over the period 1970- 2000.

Also, with regard to the *industrial* and *services* sectors, we have considered real government expenditure as an explanatory variable. Government expenditure is measured as aggregate revenue and capital expenditures of the central and state governments less defense expenditures and interest payments. It must be noted that we venture to combine both demand and supply factors in the determination of the overall level of economic activity in both industrial and services sectors. The agricultural sector is fully supply driven.

We use the implicit price deflator to calculate government expenditure in real terms at 1999-00 prices at *billions of rupees*. Data on all the other variables were taken from two major databases namely, *Handbook of Statistics on the Indian Economy* published by Reserve Bank of India, and the *National Accounts Statistics (NAS)* of India published by Central Statistical Organisation (CSO). The chosen sample period is *1970-71* through *2008-09*.

We adopt the following notations in the *model* as is given below.

NOTATION	**VARIABLE**
ZAG	Real GDP in the agricultural sector
ZIN	Real GDP in the industrial sector
ZSR	Real GDP in the services sector
ZGDP	Total real GDP
KAG	Real capital stock in the agricultural sector
KIN	Real capital stock in the industrial sector
KSR	Real capital stock in the services sector
$\hat{ZAG}$	Real GDP growth rate in the agricultural sector

$\hat{ZIN}$	Real GDP growth rate in the industrial sector.
$\hat{ZSR}$	Real GDP growth rate in the services sector
$\hat{ZGDP}$	Growth rate of total real GDP
$\hat{LAND}$	Growth rate of acreage under cultivation
$\hat{KAG}$	Growth rate of real capital stock in the agricultural sector
$\hat{KIN}$	Growth rate of real capital stock in the industrial sector
$\hat{KSR}$	Growth rate of real capital stock in the services sector
$Z\,\mathrm{Pr}\,InAg$	Real Private Sector Investment in agriculture
$ZPubInAg$	Real Public Sector investment in agriculture
$ZtotInAg$	Real total investment in agriculture
$Z\,\mathrm{Pr}\,InInd$	Real Private Sector investment in Industry
$ZPubInInd$	Real Public sector investment in Industry
$GovtExp$	Aggregate Real Government Expenditure
$\hat{GovtExp}$	Growth rate of aggregate real government expenditure
$\overline{G}$	Existing Levels of real government expenditure
G_{PA}	Policy adjustments in real government expenditure
$\overline{K}$	Existing levels of aggregate real capital stock in agriculture
K_{PA}	Policy adjustments in aggregate real capital stock in agriculture

The structural model in keeping with the foregoing discussion is as follows –

$$\hat{ZAGR} = \alpha_0 + \alpha_1 * \hat{LAND} + \alpha_2 * \hat{KAG} + \alpha_3 * \hat{ZAG}(-1) + \alpha_4 * RAINFALL \quad \textbf{(2.1)}$$

$$\hat{ZIND} = \beta_0 + \beta_1 * \hat{KIN} + \beta_2 * \hat{ZAG} + \beta_3 * \hat{ZAG}(-1) + \beta_4 * GovtExp \quad \textbf{(2.2)}$$

$$\hat{ZSRV} = \delta_0 + \delta_1 * \hat{ZAG} + \delta_2 * \hat{ZAG}(-1) + \delta_3 * \hat{ZIN} + \delta_4 * \hat{ZIN}(-1) + \delta_5 * \hat{KSR} + \delta_6 * GovtExp \quad \textbf{(2.3)}$$

$$\hat{ZGDP} = \gamma_0 + \gamma_1 * \hat{ZAG} + \gamma_2 * \hat{ZIN} + \gamma_3 * \hat{ZSR} \quad \textbf{(2.4)}$$

$$Z\,\Pr\, InAgr = \phi_0 + \phi_1 * ZPubInAg + \phi_2 * ZAG \quad \textbf{(2.5)}$$

$$Z\,\Pr\, InInd = \eta_0 + \eta_1 * ZPubInInd + \eta_2 * ZIN + \eta_4 * ZtotInAg \quad \textbf{(2.6)}$$

$$GovtExp = \overline{G} + G_{PA} \quad \textbf{(2.7)}$$

$$KAG = \overline{K} + K_{PA} \quad \textbf{(2.8)}$$

An important feature of the above model that is relevant from a *theoretical* perspective is with regard to the treatment of *agricultural sector*. It relates to the question of whether agricultural output could be treated as *exogenous* or *endogenous*. There are studies such as Chaudhuri and Rao (2004), which examine whether agricultural performance in the *long run* could be truly considered as *exogenous*. As stated earlier, we have considered it to be *exogenous* in so far as it depends on acreage under cultivation, rainfall and capital stock. The question, however, is whether these variables are themselves influenced by the developments in other sectors. We leave this open for the present. We may also note here that the fourth equation of the model could be treated as an identity for each year. But we find it easier to estimate it so as to obtain an appropriate relationship. Fortunately it works well that way.

Another significant feature of the above model is the consideration of the relationship between *public* and *private* investment in *agriculture* as well as *industry* in order to understand whether public investment in these sectors leads to *crowding-in* or *crowding-out* of private investment. A noteworthy feature of the model is the endogenity of aggregate real government expenditure as well as real capital stock in the agricultural sector. Both these variables are considered here as the sum of their existing levels, and changes in their levels resulting from policy adjustments. In the present study, four different policy adjustments are considered, the details of which are discussed in section 4.

3. Empirical Results

Before going into the estimation of the model, stationarity of the relevant variables was looked into on the basis of the *Augmented Dickey – Fuller (ADF) test*. The results are indicated in the table no. 3, below.

Table 3

Results of the Augmented Dickey Fuller (ADF) Test on the variables

VARIABLE	LEVEL	FIRST DIFFERENCE	INFERENCE*
ZAG	-3.032	-11.221	Nonstationary – I(1)
$\hat{ZAG}$	-10.736		Stationary - I(0)
ZIN	1.009	-3.415	Nonstationary – I(1)
$\hat{ZIN}$	-4.877		Stationary - I(0)
$\hat{ZSR}$	-4.833		Stationary - I(0)
$\hat{ZGDP}$	-7.679		Stationary - I(0)
$\hat{LAND}$	-8.295		Stationary – I(0)
$\hat{KAG}$	-3.916		Stationary – I(0)
$\hat{KIN}$	-1.302	-3.831	Nonstationary – I(1)
$\hat{KSR}$	-5.582		Stationary – I(0)
Z Pr *InAg*	-2.652	-9.462	Nonstationary – I(1)
ZPubInAg	0.868	-3.299	Nonstationary – I(1)
Z Pr *InInd*	1.476	-3.554	Nonstationary – I(1)
ZPubInInd	-1.337	-5.208	Nonstationary – I(1)
ZtotInAg	-1.672	-9.347	Nonstationary – I(1)
GovtExp	1.985	-5.263	Nonstationary – I(1)
$\hat{GovtExp}$	-7.624		Stationary – I(0)
RAINFALL	-7.005		Stationary – I(0)

* In a couple of cases, we had to use 5 or 10 per cent level of significance

3.1 Sectoral Growth Rates

The specified model was estimated using the *Ordinary Least Squares (OLS)* with specification of each equation in conformity with the stationarity requirements. The sample period for the equations is 1970- 2008. The results are presented as follows[6]. For *agricultural* output, we have the estimated equation as:

$$\hat{ZAG} = \underset{(-3.41^{**})}{-19.149} + \underset{(3.96^{**})}{0.820^{*}}\, \hat{LAND} - \underset{(-6.57^{**})}{0.409^{*}}\, \hat{ZAG}(-1) + \underset{(3.84^{**})}{0.026^{*}}\, RAINFALL + \underset{(1.86)}{0.555^{*}}\, \hat{KAG}(-3) + \underset{(5.85^{**})}{5.454^{*}}\, DUM1 \qquad \textbf{(3.1)}$$

$$R^2 = 0.89 \qquad \bar{R}^2 = 0.88 \qquad Durbin\_h = -0.176$$

Although rainfall is one of the explanatory variables in the above estimated equation, it does not fully capture the outliers associated with some of the drought years. For this reason, we also include the dummy variable DUM1 which takes into account such specific years namely, 1976-‘77 and 1979-‘80. These were specific drought years which were characterized by negative output growth rates. DUM1 is assigned a value of -1 for the year 1976-‘77. For the year 1979-‘80, DUM1 was assigned a value of -2, to suitably account for the severe drought conditions during this year which resulted in a highly negative output growth rate of about -12.7 per cent.

With respect to *industry* we have the corresponding output equation as follows:

$$\hat{ZIN} = \underset{(3.93^{**})}{2.891} + \underset{(2.42^{*})}{0.899^{*}}\, D(\hat{KIN}) + \underset{(4.31^{**})}{0.365^{*}}\, \hat{ZAG} + \underset{(3.24^{**})}{0.250^{*}}\, \hat{ZAG}(-1) + \underset{(1.58)}{0.095^{*}}\, \hat{GovtExp}(-1) + \underset{(4.43^{**})}{6.221^{*}}\, DUM2 \qquad \textbf{(3.2)}$$

$$R^2 = 0.60 \qquad \bar{R}^2 = 0.54 \qquad D.W = 2.18$$

A dummy variable is included in the above model to take account of specific outliers which could not be captured by the other independent variables incorporated in the model. In

[6] The figures in the brackets in each equation indicate the *t-values* of the respective coefficients. The *t-values* are appended with a * notation wherein, * indicates significance at 5per cent level whereas, ** indicates significance at 1per cent level.

particular, monetary and fiscal stimuli which we do not introduce would have definite impact on industry. These effects are sought to be captured by the dummy variable DUM2. The dummy variable is considered for the years 1994-‘95, 1995-‘96, and 2002-‘03. It takes a value of 1 for each of these years and 0 for the other years.

For the services sector, the estimated equation is as follows:

$$\hat{ZSR} = \underset{(4.68^{**})}{2.961} + \underset{(4.18^{**})}{0.230^{*}}\, \hat{KSR}(-1) + \underset{(1.89)}{0.144^{*}}\, \hat{ZIN}(-2) + \underset{(5.70^{**})}{0.00428^{*}}\, D(GovtExp) \quad \textbf{(3.3)}$$

$$+ \underset{(2.93^{**})}{0.148^{*}}\, \hat{ZAG} + \underset{(3.59^{**})}{0.181^{*}}\, \hat{ZAG}(-1) + \underset{(4.19^{**})}{3.914^{*}}\, DUM3$$

$$R^2 = 0.70 \qquad \bar{R}^2 = 0.64 \qquad D.W = 1.79$$

The dummy variable DUM3 is considered for three outlier time periods, namely, 1978-‘79, 1995-‘96, and 2008-‘09. It takes a value of -1 for the years 1978-‘79 and 2008-‘09, a value of 1 for the year 1995-‘96, and 0 for the remaining years.

Finally we link the three sectoral growth rates with the overall GDP growth rate by the following equation:

$$\hat{ZGDP} = \underset{(-2.06^{*})}{-0.368} + \underset{(30.87^{**})}{0.371^{*}}\, \hat{ZAG} + \underset{(12.61^{**})}{0.199^{*}}\, \hat{ZIN} + \underset{(13.35^{**})}{0.482^{*}}\, \hat{ZSR} - \underset{(-1.02)}{0.290^{*}}\, DUM4 \quad \textbf{(3.4)}$$

$$- \underset{(-4.89^{**})}{0.114^{*}}\, SLOPEDUMAGR + \underset{(3.45^{**})}{0.149^{*}}\, SLOPEDUMSER - \underset{(-1.65)}{0.314^{*}}\, AR(1)$$

$$R^2 = 0.99 \qquad \bar{R}^2 = 0.99 \qquad D.W = 1.84$$

The estimated coefficients reflect the average shares of the respective sectors in the total GDP. Since the time period of study is from 1970-‘71 onwards, it can be said that the average share of agricultural sector in the total GDP from 1970-‘71 to about 1989-‘90 was around 37 per cent , and those of the industrial and services sectors were around 20per cent and 48per cent respectively. We have incorporated two slope dummies and one intercept dummy variable to take care of the structural changes since the early nineties. The slope dummy for the agricultural sector is SLOPEDUMAGR and that for the services sector is

SLOPEDUMSER. As expected, the sign of the agricultural sector slope dummy is negative, indicating a decline in its share in the total GDP. The sign of the services sector slope dummy is positive, indicating an increase in its share in the total GDP. Thus from the nineties onwards, the average shares of the respective sectors in the total GDP have gone up for Services from 48per cent to 63per cent and gone down for agriculture from 37per cent to 26 per cent . The contribution of industry remains unchanged at about 20per cent. DUM4 is the intercept dummy used in consonance with the slope dummies. As expected, the overall fit of the equation is very good, in keeping with the fact that this more or less approximates an identity as stated earlier.

On the whole, the general fit of the *four* estimated equations is very good. The equations clearly bring out the linkages that exist among the three sectors implying that poor performance of any sector, particularly agriculture, would affect the performance of the other sectors of the economy and thereby, the economy on the whole. Agriculture enters into the industrial sector equation as an independent variable, and agricultural and industrial sectors enter as independent variables in the service sector equation. If the above *four* equations are viewed as a system of simultaneous equations comprising four endogenous variables, we can see that the solution of this system is obtained recursively.

3.2 The Crowding-in of Investment

The relationship between *public* and *private* investments in the agricultural as well as industrial sector is examined for the sample period 1970- 2007 as follows.

$$D(Z\ \mathrm{Pr}\ InAg) = \underset{(0.98)}{319.92} + \underset{(2.10^{*})}{0.557}{}^{*}\, D(ZPubInAg) + \underset{(7.52^{**})}{10091.49}{}^{*}\, DUMAG - \underset{(-2.33^{*})}{0.378}{}^{*}\, AR(1) \qquad \textbf{(3.5)}$$

$R^2 = 0.70$ $\qquad$ $\overline{R}^2 = 0.67$ $\qquad$ $DW = 2.00$

Public investment seems to notably *crowd-in private* investment in agriculture. This is seen from the large, positive and highly statistically significant coefficient of public

investment in the above equation. DUMAG is a dummy variable which is equal to -1 for the years 1991 and 2003, and +1 for the two years 1990 and 1999, takes care of exceptional years of the two types.

For the *industrial* sector, the estimated equation is as follows -

$$D(Z\ \mathrm{Pr}\ InInd) = \underset{(-2.61)}{-8575.513} + \underset{(2.12^{*})}{0.755}^{*} D(ZPubInInd(-1)) + \underset{(6.52^{**})}{1.105}^{*} D(ZIN) + \underset{(1.98^{*})}{0.714}^{*} D(ZtotInAg)$$
$$+ \underset{(5.85^{**})}{29048.13}^{*} DUMIN + \underset{(0.94)}{0.182}^{*} AR(1)$$

$$R^2 = 0.81 \qquad \overline{R}^2 = 0.78 \qquad DW = 1.90 \qquad \textbf{(3.6)}$$

The clear indication is that *public* investment significantly *crowds-in* private investment more strongly in the industrial sector than in the agricultural sector. However, the impact is seen to occur with a one-period lag. Private investment in industry is also significantly influenced by the total investment in agriculture as well as by aggregate real output in the industrial sector. DUMIN is a dummy variable equal to -1 for the years 2000 and 2007, and +1 for the years 2003, 2004 and 2008, which are outliers. One can infer from the above *two* equations that the *crowding-in* process is quite strong in both the agricultural and the industrial sectors. Thus, any policies to boost investments in these sectors would necessarily require the public sector to play a pivotal role so as to trigger significant private sector investments into the respective sectors.

4. Policy Implications of the Model

We now turn to examine the implications of the estimated structural model. For this, we undertake four *counterfactual simulation exercises* under alternative policy scenarios. All of these relate to public investment in agriculture. To ensure validity of the exercise, let us first look at the accuracy of the estimated model, using the *Root Mean Square Percentage Error* (RMSPE) criterion. The critical endogenous variables in the model are chosen for this test for

different time periods within the overall sample period. The calculated values reported in Table A.1 appendix A, indicate that the predictive performance of the model is fairly good. However, the deviation is relatively high for agricultural output for the period 2000-01 through 2007-08. This is expected in view of the high fluctuation that has characterized agricultural performance over this period. Nevertheless, the model as a whole performs reasonably well for the entire sample period and appears to be considerably good for policy analysis. The fact that the turning points in the dependent variables are very well captured is reassuring.

The four simulation exercises focusing on the policy for *public* investment in agriculture, for the period 1995-2008 are as follows :-

(a) Scenario A – The level of public investment in agriculture in fixed at a sustained level of Rs. 100 billion for each year.

(b) Scenario B – The growth rate of real public investment in agriculture is taken to be 10 per cent higher than the actual rate.

(c) Scenario C – The rate of real public investment in agriculture (i.e., public investment as a percentage of overall GDP) is fixed at 0.5 percent.[7]

(d) Scenario D- The rate of real public investment in agriculture is fixed at 1 percent.

We analyze the impact of these changes on the levels of private investment in agriculture, and then, on the sectoral growth rates. As stated earlier, increase in *public* investment into agriculture will have to be supported by a corresponding increase in the overall government expenditure which must look manageable. Higher growth in agriculture will raise growth rates in industry and services. The results are reported in Tables 4, 5A, 5B, and 6. In table 4,

[7] The actual rate of public investment in agriculture has remained well below 0.5% during the latter half of 90s, right up to the year 2006.

we show the crowding-in effect of public investment on private investment in agriculture. In tables 5A and 5B, we show the impact of these changes on the sectoral growth rates[8].

Table 4

Crowding-in Effect of Public Investment on Private Investment in Agriculture

(Rupees Billion)

YEAR	Scenario A	Scenario B	Scenario C	Scenario D
1995-96	24.26	0.40	6.68	46.41
1996-97	28.35	3.68	13.59	56.69
1997-98	36.97	5.67	23.65	68.45
1998-99	36.04	10.71	27.53	73.43
1999-00	30.47	13.79	22.31	73.15
2000-01	32.07	15.56	24.55	79.04
2001-02	24.58	26.08	18.53	75.47
2002-03	32.17	25.09	28.54	87.36
2003-04	20.47	45.51	23.46	87.56
2004-05	8.70	69.97	14.56	83.84
2005-06	-3.54	99.70	7.38	82.98
2006-07	-22.23	146.01	-3.34	78.23
2007-08	-37.31	201.40	-13.81	73.89
2008-09	-54.66	267.98	-24.63	74.59

The results in table no. 4 indicate that there is significant crowding-in effect of public investment on private investment in agriculture. The last few entries in columns 1and 3 are negative. Lest it be interpreted as crowding-out effect of public investment let us note that

[8] In these tables, we only show the changes in the respective variables. Changes here refer to the difference between the simulated values and the baseline solution. We present the baseline values for certain important variables in appendix B. The baseline values of the exogenous variables are the actual values, and for the endogenous variables are the solved values.

this is due to the fact that during these years, the rate of public investment in agriculture was more than 0.5% and its magnitude was more than Rs. 100 billion. This apparent perversity gets reflected in all other subsequent calculations. For this reason, we may focus on the sample period up to 2005-06.

Table 5A

Increase in Growth Rates Under Different Scenarios

(Percent per Annum)

Year	Scenario A				Scenario B			
	Agriculture	Industry	Services	Total GDP	Agriculture	Industry	Services	Total GDP
1995-96	0.07	0.11	0.21	0.16	0.00	0.12	0.01	0.03
1996-97	-0.07	0.28	0.04	0.05	-0.05	-0.18	0.02	-0.04
1997-98	-0.03	0.01	0.14	0.07	-0.08	-0.02	0.05	0.00
1998-99	0.70	0.39	0.22	0.44	0.12	-0.10	0.03	0.05
1999-00	0.40	0.17	0.07	0.21	0.15	0.21	0.05	0.11
2000-01	0.64	0.12	0.15	0.34	0.04	0.00	0.04	0.04
2001-02	0.61	0.58	0.20	0.43	0.16	0.24	0.16	0.18
2002-03	0.46	0.11	0.21	0.31	0.21	0.13	-0.07	0.07
2003-04	0.58	0.14	0.20	0.33	0.30	-0.19	0.36	0.25
2004-05	0.46	0.08	0.06	0.22	0.66	0.68	0.36	0.56
2005-06	0.46	0.17	0.04	0.22	0.31	0.33	0.35	0.34
2006-07	0.08	-0.12	-0.07	-0.03	0.86	0.74	0.66	0.78
2007-08	-0.01	0.03	-0.13	-0.05	1.08	0.79	0.82	0.98
2008-09	-0.24	-0.22	-0.22	-0.26	1.76	1.21	1.06	1.38

Table 5B

Increase in Growth Rates Under Different Scenarios

(Percent per Annum)

Year	Scenario C				Scenario D			
	Agriculture	Industry	Services	Total GDP	Agriculture	Industry	Services	Total GDP
1995-96	-0.11	-0.05	0.07	-0.02	0.01	-0.01	0.39	0.18
1996-97	0.09	0.11	-0.02	0.05	0.06	0.92	0.12	0.28
1997-98	0.01	0.19	0.13	0.10	-0.10	-0.08	0.08	-0.01
1998-99	0.23	0.27	0.13	0.20	1.19	0.72	0.30	0.74
1999-00	0.34	0.11	0.04	0.16	0.93	0.22	0.28	0.53
2000-01	0.44	-0.08	0.15	0.23	1.25	0.61	0.48	0.81
2001-02	0.44	0.43	0.10	0.28	1.25	0.81	0.49	0.86
2002-03	0.51	0.12	0.21	0.32	1.02	0.49	0.45	0.68
2003-04	0.39	0.42	0.28	0.35	1.22	0.59	0.46	0.80
2004-05	0.36	0.05	0.14	0.21	0.97	0.36	0.41	0.63
2005-06	0.57	0.02	0.09	0.25	1.23	0.61	0.40	0.77
2006-07	0.31	0.24	0.12	0.21	1.07	0.69	0.39	0.73
2007-08	0.00	0.03	-0.03	0.00	0.86	0.23	0.39	0.56
2008-09	0.11	0.00	0.00	0.04	0.98	0.46	0.39	0.63

Tables 5A and 5B, show how the sectoral and total GDP growth rates get raised resulting from the increase in public investment in agriculture under the alternative scenarios. These are significant enough to reveal the important role played by the policy under which *public* investment in agriculture is augmented. We also calculate the required percentage increase in the aggregate real government expenditure, resulting from an increase in public investment in agriculture. This is mainly to check the practical feasibility of alternative policy alternatives.

Calculations reported in table 6 indicate that all of these policy alternatives are feasible, since the required percentage increase in the aggregate government expenditure is very much within manageable limits. We may nevertheless take a conservative view and consider scenario C to be particularly acceptable. Let it be recalled that under this scenario, real public investment in agriculture is restricted to 0.5% of total real GDP. This implies that real government expenditure rises at the most by about 1 percent which cannot be turned down on any account. Let us note that there is a substantially higher crowding-in effect; the rate of growth in agriculture is higher by about 0.5 percent; and, the rate of real GDP growth is higher by 0.25 to 0.4 percent. All most desirable at a low cost.

Table 6

Increased Real Government Expenditure under the Alternative Scenarios

(Percent per annum)

Year	Scenario A	Scenario B	Scenario C	Scenario D
1995-96	1.28	0.16	0.47	2.40
1996-97	1.42	0.29	0.76	2.74
1997-98	1.63	0.34	1.13	3.10
1998-99	1.45	0.43	1.13	2.98
1999-00	1.23	0.59	0.94	2.88
2000-01	1.24	0.63	1.03	2.94
2001-02	0.89	0.94	0.79	2.65
2002-03	1.03	0.81	1.03	2.74
2003-04	0.57	1.18	0.73	2.33
2004-05	0.27	1.76	0.45	2.20
2005-06	-0.03	2.62	0.32	2.27
2006-07	-0.4	3.27	0.05	1.86
2007-08	-0.73	4.29	-0.18	1.70
2008-09	-0.92	4.81	-0.35	1.44

5. Conclusions and Policy Implications

The present study is basically motivated by concern for a lower and fluctuating growth of India's agricultural sector with its implications not only for food security, but also overall GDP growth. To pursue this, we set out to identify inter-sectoral linkages in the Indian economy and the phenomenon of crowding-in associated with public investment. This has meant that we take into account the relationship between *public* and *private* sector investments in agriculture and industry. The three sectors considered for the study are *agriculture*, *industry* and *services*. To begin with, a model for output growth is estimated for each of the three sectors linked with total GDP growth. Results do indicate a strong influence of the *agricultural* sector on the *industrial* sector, and a strong influence of the agricultural and industrial sectors on the *services sector*.

With regard to the relationship between *public* and *private* sector investments, the results indicate a significant *crowding-in* impact of *public* investment on *private* investment in both *agricultural* as well as *industrial* sectors. Since proper validation tests indicate the model to be reliable, it is solved under four alternative policy scenarios all of which indicate substantial *crowding-in* impact of *public* investment in agriculture. Increased levels of public and private investment in agriculture lead to an increase in the overall agricultural capital stock.

To examine policy feasibility we also look at increase in the levels of aggregate government expenditure on account of increase in *public* investment in agriculture. Though all the four policy packages look feasible, we take a conservative view. We consider a 0.5 percent of real GDP as one which should be widely acceptable. We may note that higher public investment in agriculture in recent years is most welcome if we want to ensure sustained higher growth in GDP and a movement towards ensuring food security. Finally, let us note that this paper attempts to visit an old problem which has assumed greater

seriousness in recent years. The latest information incorporated in a rigorous exercise takes into account the crowding-in phenomenon, intersectoral linkages, a joint supply-demand system and the question of a feasible policy prescription. The conclusion is quite clear. Policy makers in India need to once again pay adequate attention to public investment in agriculture.

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Appendix A

Table A.1

Root Mean Square Percentage Error

Equation No.	Dependent Variable	1975-2008	1975-1995	1995-2000	2000-2008
1.	Agricultural Growth Rate $\widehat{ZAG}$	0.9075	0.6119	0.7902	2.2308
2.	Industrial Growth Rate $\widehat{ZIN}$	0.6237	0.7877	0.5181	0.4931
3.	Services Growth Rate $\widehat{ZSR}$	0.1975	0.2366	0.2504	0.2518
4.	Total GDP growth Rate $\widehat{ZGDP}$	0.2805	0.3485	0.3105	0.2683
5.	Private Capital Formation (Agriculture) $ZPrInAg$	0.6146	0.7777	0.4287	0.2649
6.	Private Capital Formation (Industry) $ZPrInInd$	0.6232	0.7354	0.3271	0.2828

Appendix B

Baseline Solutions for Important Variables

Table B.1: Investment and Government Expenditure

Year	Real Public Investment in Agriculture (Rs. Billion)	Real Private Investment in Agriculture (Rs. Billion)	Aggregate Real Government Expenditure (Rs. Billion)
1995-96	54.06	38.38	3597.35
1996-97	46.59	32.45	3766.342
1997-98	34.36	31.38	4031.794
1998-99	35.56	32.89	4444.247
1999-00	41.52	142.88	4746.219
2000-01	37.18	144.08	5073.558
2001-02	51.59	155.52	5428.744
2002-03	38.80	151.34	5968.309
2003-04	59.58	65.17	7088.391
2004-05	80.47	80.00	7210.693
2005-06	101.88	95.11	6936.285
2006-07	132.05	116.00	8054.566
2007-08	162.33	135.56	8482.774
2008-09	192.54	156.08	10062.04

Baseline Solutions for Important Variables

Table B.2: Sectoral Growth Rates

Year	Agriculture	Industry	Services	Total GDP
1995-96	1.32	9.35	10.21	8.12
1996-97	4.81	5.17	7.34	5.61
1997-98	2.71	4.81	7.89	6.75
1998-99	2.47	5.19	7.33	5.32
1999-00	0.13	4.46	6.50	4.52
2000-01	-0.22	2.65	6.37	3.74
2001-02	1.58	3.60	4.56	3.17
2002-03	-6.28	8.90	6.04	3.63
2003-04	11.54	9.73	9.79	10.49
2004-05	-2.08	9.52	7.73	5.69
2005-06	4.45	5.22	9.94	7.70
2006-07	3.46	6.82	12.07	9.15
2007-08	4.58	6.36	8.65	7.58
2008-09	4.20	6.47	10.15	8.32