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**DO MACROECONOMIC
CONDITIONS MATTER
FOR AGRICULTURE?
THE INDIAN EXPERIENCE**

Shashanka Bhide

Meenakshi Rajeev

B P Vani

**INSTITUTE FOR SOCIAL AND ECONOMIC CHANGE
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DO MACROECONOMIC CONDITIONS MATTER FOR AGRICULTURE? THE INDIAN EXPERIENCE

By **Shashanka Bhide, Meenakshi Rajeev and B P Vani***

Abstract

Macroeconomic instability, characterised by high inflation, a fragile foreign exchange position, high rates of interest, increases uncertainty for any investor or producer and hence slows down economic growth. While this is generally accepted, the usual perception about the agricultural sector, particularly in India, is that it is immune to general macroeconomic shocks. In this paper, we intend to examine this perception formally using a vector auto regressive model. By studying the significance of macroeconomic conditions to the agricultural sector, we observe that the sector is not insulated from macroeconomic shocks.

Introduction

A conducive macroeconomic environment is necessary for rapid economic growth. Macroeconomic instability, characterised by high rates of inflation, a fragile foreign exchange position, high rates of interest, increases uncertainty for any investor or producer and hence slows down economic growth. Besides these direct indicators, macroeconomic instability may also be indicated by overall imbalances such as the fiscal balance and external current account balance, especially when prices are under administrative controls. An underlying assumption in these arguments is that production sectors are influenced by macroeconomic conditions. Any attempt to examine this proposition will require identification of the indicators of macroeconomic conditions and of the performance of the sectors.

In the Indian context, the agricultural sector has been important from a policy perspective for several reasons. Even from the point of view of accelerating economic growth, transition from an agrarian economy to an industrial or modern economy would depend on how well the agricultural sector enables this transition. Therefore, besides the concerns relating to employment and poverty alleviation, the performance of agriculture is of policy interest from the viewpoint of accelerating economic growth as well. In this context, the general belief is that overall

* Shashanka Bhide is Professor, Meenakshi Rajeev is Associate Professor and B P Vani is Assistant Professor at the Institute for Social and Economic Change, Bangalore. The authors wish to acknowledge the research assistance of Ms. G Aparna in the preparation of this paper. Views expressed here are those of the authors alone and do not necessarily represent the views of ISEC.

macroeconomic policies have little effect on the agricultural sector and that we need sector-specific policies to boost this primary sector of the economy. While the latter may be true, the macroeconomic environment may also have non-trivial effects on the agricultural sector. It is necessary to examine this hypothesis more rigorously, as if it does influence agricultural performance, it would be important to understand the significance of this impact in designing policies for agriculture.

The key to understanding the impact of changes in macroeconomic parameters at the sectoral level is the transmission mechanism of these policy impulses to the various sectors both directly and indirectly through inter-sectoral relationships. Such impact assessment is often made in the framework of macroeconomic models in which agriculture and other sectors are featured in detail. Rangarajan (1982) provides one of the early attempts at estimating the inter-linkages between agriculture and industry. There are other studies, such as those of Narayana, Parikh and Srinivasan (1991), Strom (1993) and Kalirajan and Bhide (2003), where the impact of macroeconomic policies on agriculture is simulated using economy-wide models for India. Shand and Kalirajan (1999) provide another approach at capturing these linkages where they examine inter-sectoral dependence through Granger causality tests. Both these approaches capture two-way links: from agriculture to the non-agricultural sectors and vice-versa within an implicit or explicit specification of a macroeconomic environment. In one of its recent reports, the Reserve Bank of India (2002) draws attention to the impact of rising food subsidies on macroeconomic conditions. However, the analysis is limited to the one-way linkage.

India saw very wide-ranging changes in macroeconomic policies in the 1990s. The changes at the macroeconomic level were changes in the fiscal and financial sectors, trade and investment policies. It has been argued that agriculture was only indirectly affected by these reforms. The industrial sector was most affected directly by the removal of the production licensing system enforced through control over new investments. Changes in the financial sector including exchange rate policies and attempts to stabilize fiscal imbalance, however, can be expected to have an impact across all the sectors. How important was this impact to agriculture?

Economy-wide models, of macroeconomic variety or the CGE type, provide a comprehensive analytical structure for analysis. One limitation of the macroeconomic models is of course that much effort

is needed to build the structural equations that incorporate the various inter-relationships and it is often difficult to check for the impact of changes in policies due to changes in the structure. A more flexible approach to the assessment of the impact of impulses emanating from the macroeconomic factors to agriculture is the framework of time-series analysis. We should note at the outset that the VAR approach essentially captures the 'reduced form' relationships among the selected variables. Interpreting the estimated linkages in a theoretical framework is not easy because the theoretical specification is not complete in a VAR.

This paper is an attempt to assess the nature of the inter-relationship between selected macroeconomic factors and agriculture using the vector auto regression (VAR) approach. The VAR approach provides a general framework for assessing the impact of inter-related variables¹. The general framework of analysis we adopt here is to first specify a set of variables that capture the performance of agriculture and a set of variables that specify the macroeconomic environment. The agricultural variables we consider are real agricultural GDP, agricultural exports and fixed investment in agriculture. The last mentioned variable is measured through the gross fixed capital formation (both public and private) in the agriculture sector. The macroeconomic variables are interest rate, foreign exchange rate of the rupee and fiscal deficit of the Central Government. We then use two methods of quantifying the impact of macroeconomic factors on agriculture. One approach is to estimate the VAR and the impulse response functions. The second approach is the variance decomposition to quantify the impact of the macroeconomic factors on agriculture. We have used annual data for the period 1970-71 to 2000-01 for the analysis. This period covers a variety of experiences both in macroeconomic conditions, agricultural performance and policies.

The rest of this paper is devoted to the presentation of the results of analysis and discussion of the findings. To provide a context for the analysis that follows, we briefly review the trends in some of the major macroeconomic variables and discuss the likely impact of these changes on agriculture. We then present a discussion of the trends in selected macroeconomic variables, followed by methodology and results of the VAR analysis respectively. A concluding section follows at the end.

Conceptual Framework

India's macroeconomic policies have generally attempted to ensure adequate resources for the investment programmes of the public sector while maintaining adequate supplies of essential commodities for mass

consumption. Sectoral policies, whether in agriculture or industry, were cast within the overall framework of macroeconomic goals. India's macroeconomic stabilisation programme of the 1990s that preceded and then overlapped the structural adjustment reforms aimed at reducing the fiscal imbalance, reducing the current account deficit, moderating inflation, correcting the overvalued foreign exchange rate and bringing down interest rates. The emphasis on public sector investment has changed to investment that is commercially viable. While food security and economic growth remain critical objectives, there is greater stress on maintaining the conducive macroeconomic environment rather than on direct public investment at the micro level. Do these changes have an impact on agriculture? To attempt an assessment of this question, we will need to identify the factors that describe the macroeconomic conditions and the variables that describe performance of agriculture. In this section, we identify these factors and variables, examine the trends in these variables over time and provide a discussion of the potential mechanisms by which the impact of changes in the macroeconomic conditions is transmitted to the agricultural sector.

Selection of Variables for Analysis:

Of the many indicators of macro-economic conditions, we focus on aggregate market imbalances and aggregate prices to discern the impact of macro-economic conditions on agriculture. The imbalances that we have chosen to reflect macro-economic conditions in this study are the fiscal imbalances of the Central Government and the external current account balances. The three aggregate prices chosen for the analysis are interest, exchange and inflation rates. Prices would reflect market conditions fully only if policy measures are not used to control these prices in the divergence of market forces. In the Indian context, although controls over prices existed, at the aggregate level, the controlled prices also saw gradual adjustments with respect to market conditions. Besides the potential for direct impact, these variables capturing the macro level imbalances and price conditions also trigger policies that may have a direct impact on specific sectors. For example, severe external balance constraints may lead to policies, that support exports. Similarly, high rates of inflation bring to focus the need for ensuring adequate supplies of essential goods of consumption and therefore greater attention to policies that raise agricultural growth.

In this sense, the choice of variables to reflect macro-economic conditions should include the indicators that not only have a direct impact on the performance of agriculture but may also influence agriculture indirectly through policies resulting from macro-economic conditions.

With these considerations, five broad measures of macro-economic conditions selected for further analysis in this study are: gross fiscal deficit of the central government (GFDC), current account balance (CAB) and interest, exchange and inflation rates.

To assess the impact of macroeconomic factors or conditions on agriculture, we also need to identify the variables that reflect the performance of agriculture. In this study, we consider the variables that capture different dimensions of agricultural sector. Agricultural investment, agricultural exports and agricultural GDP are the three variables selected in the study to reflect the performance of agricultural sector. They reflect the overall output performance of agriculture and also relate more directly to interest rate, inflation rate and exchange rate changes. Interest rate conditions affect agricultural investment and changes in exchange rate influence exports. The overall agricultural GDP is inter-linked with inflation rate and all other factors that influence either the demand or the supply of farm products.

In most cases of the above five macro-economic indicators, alternative measures are available. In the case of interest rate, a number of interest rates are available indicating the wide range of financial markets. We have selected a rate that is a benchmark for investment lending by the commercial banks. A combination of the minimum lending rate of IDBI and the Prime Lending Rate (PLR) of commercial banks (PLRX) was chosen as the interest rate for analysis in this study. In the case of exchange rate, we have selected real effective exchange rate of the rupee (REER) which is a trade weighted real exchange rate of 36 major trading partners of India. The consumer price index for industrial workers (CPI_IW) is used as an indicator of inflation rate in the present study.

The Macroeconomic Trends of the Variables

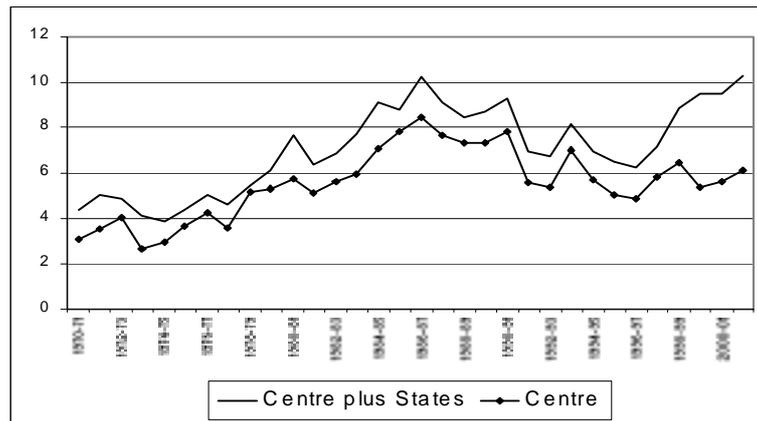
The key variables that are tracked in this section (Table A.2 in Appendix presents the data used for the study) include the two 'gaps' in macroeconomics: fiscal deficit and the current account deficit. We have focused here on the fiscal deficit of the Central Government, as the initial correction under the stabilisation program was at this level of government. In addition, we also present the trends in inflation rate, real exchange rate (REER) and interest rate².

The intense pressures of fiscal and external sector imbalances at the time of the macroeconomic crisis of 1990/1991 are well known. The macroeconomic crisis triggered many economic policy changes.

Two of the key indicators that reflected the crisis were the fiscal and external imbalances.

Attention was focused on the gross fiscal deficit of the Central Government although the overall fiscal imbalance is known to be much higher than this deficit. Figure 1 presents the trends in fiscal deficit at the Central Government level and for comparison the Centre *plus* States levels for the period 1970-71 to 2002-03. We note the similarities and differences in trends in the two deficits. The pattern of deficits shown in Figure 1 indicates a similarity in their trend up to mid-1990s. Until this period of around 1996-97, there are two phases in the pattern of the trend. First, from 1970-71 to 1991-92 there is a rising trend in both the deficits. However, from 1991-92 to 1995-96, there is generally a declining trend in both the measures of fiscal deficit. From around this period of 1997-98, both the deficits rise.

Figure 1. Trends in Fiscal Deficit (% of GDP at market prices)

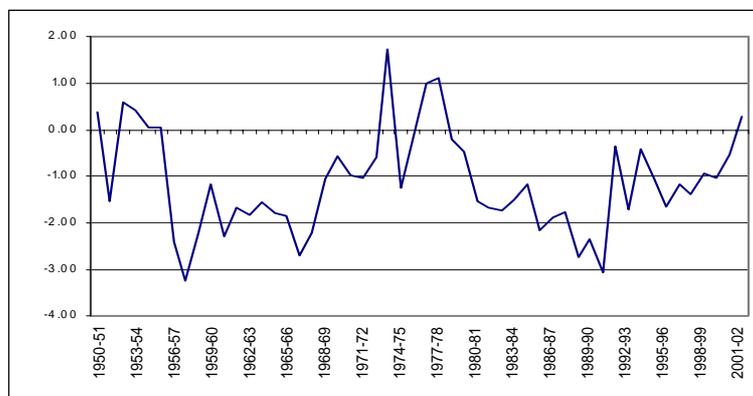


From 1999-2000 onwards, the Centre's fiscal deficit shows a declining trend and the combined deficit keeps rising up to 2001-02 and then drops slightly in 2002-03. However, the drop in the Centre's fiscal deficit since 1999-2000 is exaggerated, because of the change in the accounting of the borrowings under small savings in the Central Government budget. These trends show that fiscal deficit of the Centre and Centre *plus* States rose steadily till 1991-92 and then decreased following the stabilisation programme of the early 1990s for a while till the mid 1990s. Since then, however, the deficits have shown a tendency to rise.

In the case of external balance, CAB captures fully the conditions relating to the payment and receipts under current external transactions. The ability of the nation to finance its foreign exchange requirement of imports is reflected in the CAB, especially when the capital inflows are meager. Although there is the measure of trade balance, which covers the conditions in the merchandise trade, the current account balance is more comprehensive.

The trends in CAB are shown in Figure 2. From 1978-79 to 2000-01, the balance was always a deficit. In the 9-year period before 1978-79 up to 1970-71, there were three years in which the balance was a surplus. For a period of about 25 years since the late 1970s, the external current balance was in deficit. In some years, the deficit exceeded 2% of GDP. There was continuous improvement in the CAB, following macroeconomic stabilization and foreign exchange policy and trade policy reforms in the 1990s. Until the late 1990s, CAB was a critical factor in much of the macroeconomic policy debate. One reason for the policy sensitivity to CAB was the lack of significant capital inflows over and above the financing needs of the current account. This situation has changed dramatically especially since 1999-00. The improvement in CAB has also been accompanied by capital inflows to swell the foreign exchange reserves leading to a decline in the concern over CAB.

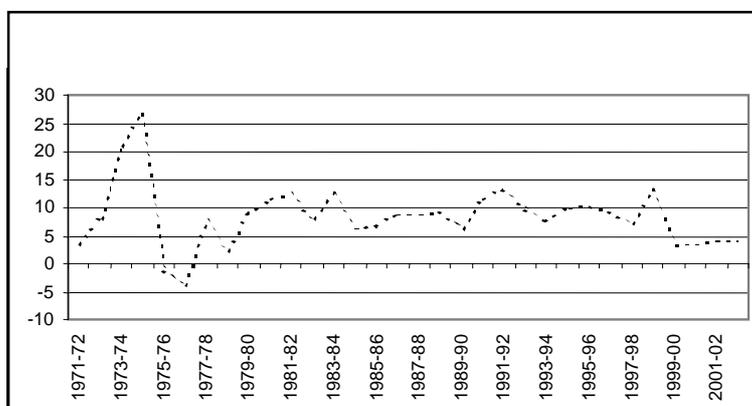
Figure 2. Trends in CAB (% of GDP at market prices)



Policy concern over CAB influenced export policies in the past. There is of course no indication of any reduction in the support for exports but given the multi-lateral trade commitments, export performances now have to depend more on intrinsic competitiveness rather than policy-indicated competitiveness.

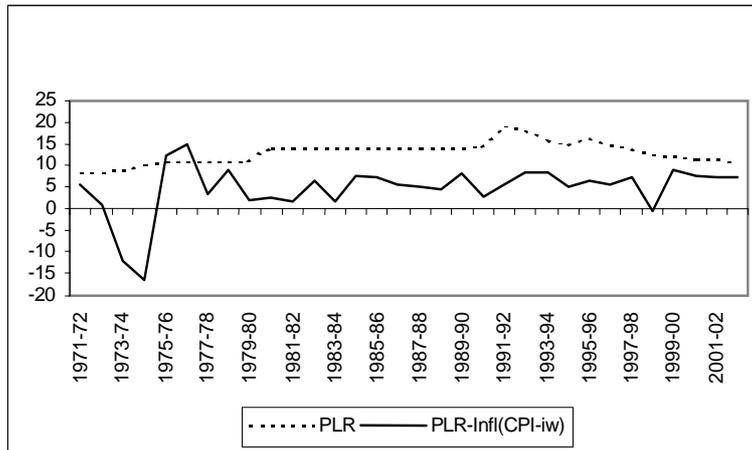
The three price- related rates of macro or aggregate markets, viz. the inflation, exchange and interest rates are shown in Figures 3-5.

Figure 3. Trends in Inflation Rate (% annual) based on Consumer Price Index for Industrial Workers



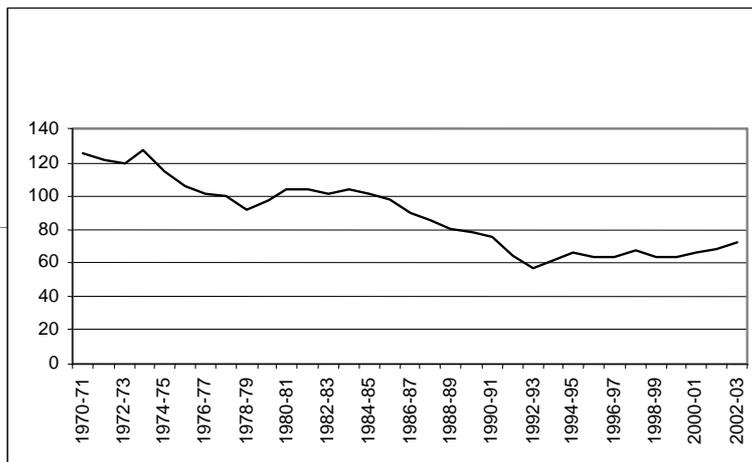
The inflation rate, CPI_IW (Figure 3 above) has seen a declining trend especially in the second half of the 1990s. After reaching double-digit level in 1991-92, the inflation rate remained above 5% during the period 1992-93 to 1998-99. It rose above 10% in 1998-99 but returned to less than 5% in the subsequent period up to 2002-03. The nominal interest rate, PLRX, increased sharply in 1991-92 and remained about 15% up to 1996-97 (Figure 4). Since 1996-97 there has been a decline in PLRX. In nominal terms, the decline is by almost 4 percentage points since the high levels of 1995-96. The decline is less marked in terms of real interest rate. However, it must be pointed out that there has been some lending below the PLR by the commercial banks indicating that trends in PLR can only be a crude proxy for the trends in interest rates in the economy. The drop in interest rates has been widely observed by both the savers and investors since the mid-1990s.

**Figure 4 : Trends in Interest Rate (Nominal and Real) :
PLR of Commercial Banks**



The real effective exchange rate, REER, saw a major correction in 1991-92 and 1992-93 after a steady depreciation for about a decade (Figure 5). Since then there has been a relatively stable period marked by a tendency towards appreciation. Although controls on external capital account transactions remain, the rupee is sensitive to supply-demand pressures in foreign exchange markets. The large levels of forex reserves moving closer to \$90 billion have led to the strengthening of the rupee.

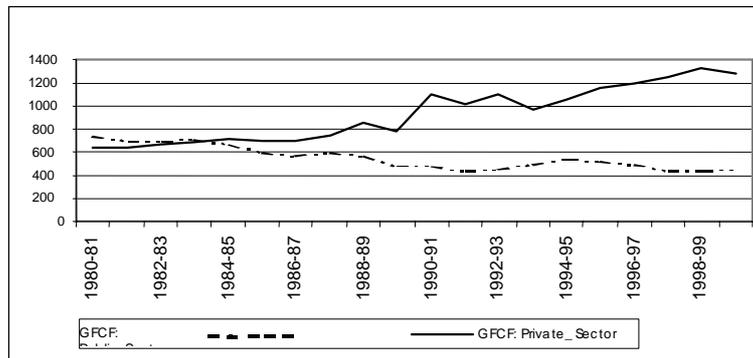
Figure 5. Trends in Exchange Rate: REER (36 country trade weighted)



Performance of Agriculture : The trends in key agricultural variables in this analysis are illustrated in Figures 6, 7 and 8. Private agricultural investment (gross fixed capital formation in constant prices), which rose sharply between 1987-88 to 1990-91, became stagnant for the next three years till 1993-94. It rose steadily again till 1998-99 after which it remained at the same level in the subsequent year. The years 1991-92 to 1993-94 were the periods when the macro-economic parameters were more unstable reflecting the adjustments in policy. The subsequent period was marked by a few years of strong growth in industry and a climate favourable for investment. This period also appears to have influenced private sector investment in agriculture. However, the public sector capital formation in agriculture has continued to stagnate for well over a decade.

Fiscal pressures on the one hand and preference for subsidies have led to stagnation in Government spending on investment in agriculture. The impact of adverse macro-economic conditions on investment is generally evident in the case of investment.

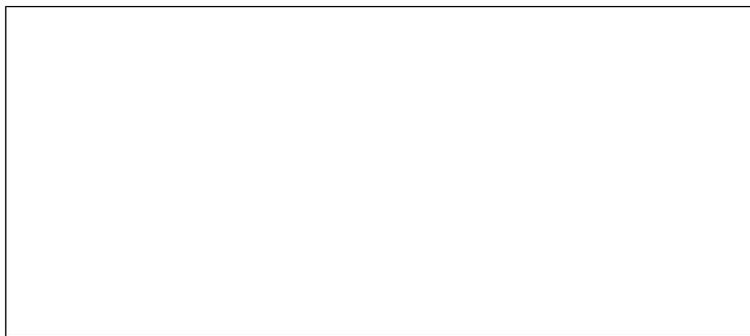
**Figure 6. Investment in Agriculture (GFCF):
Public and Private Sectors (Rs. Crore 1993-94 prices)**



Indicators of terms of trade (calculated as a ratio of wholesale price index for agricultural commodities to wholesale price index of manufacturing products) shown in Figure 7 reflect a relatively stable period from the mid-1980s to the mid-1990s. The index rose sharply between 1995-96 and 1998-99 after which there has again been a stagnation up to 2002-03. The period of stable terms of trade from the mid-1980s to mid-1990s includes the period when fiscal imbalances were growing and were high, as well as period of high rates of inflation. We also note that this has been a period when private sector capital formation

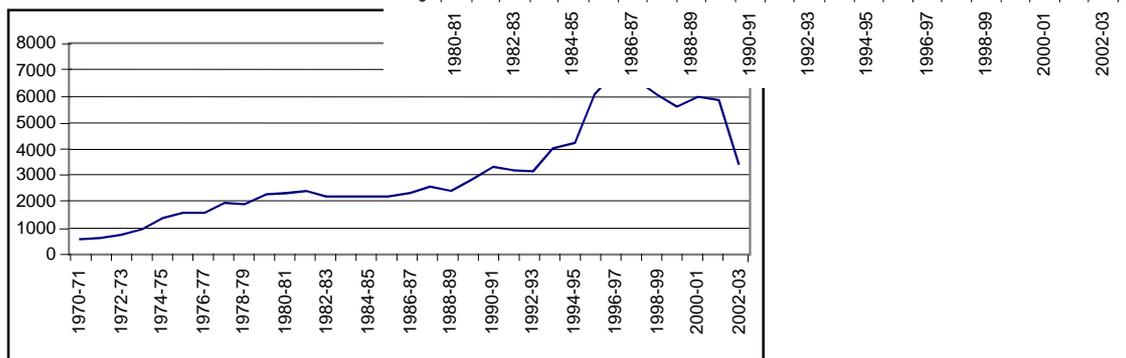
in agriculture was rising. The years since 1995-96 up to 2002-03 include a period when non-agricultural investment was also on the decline and overall inflation rate decreased especially after 1998-99. In other words, agricultural prices have kept pace with the overall inflation rate especially when the inflation rate has been relatively high. Macro-economic instability, which included high rates of inflation, was also characterised by higher growth in agricultural prices.

Figure 7. Trends in Terms of Trade: (WPI for Agriculture/WPI for Manufacturing)*100



Agricultural exports increased sharply during the period 1988-89 to 1996-97 (Figure 8). Exports in value terms declined from 1996-97 onwards. The latter decline is attributed to a decline in global demand for agricultural exports during the period when global economic growth was slow. The decline in exports has occurred despite a decline in the exchange rate which would have an impact of export prices. The decline in exports has occurred despite a decline in the exchange rate which has been relatively stable.

Figure 8. Agricultural Exports (US \$)



Methodology for Assessing the Impact of the Macroeconomic Factors

The Transmission Mechanisms

The broad trends in the macroeconomic factors and measures of agricultural performance indicate fluctuations and changes in pattern over a long period of over three decades (1970-71 to 2000-01). In the case of macroeconomic variables, the trends reveal upward and downward movements in fiscal deficit, turnaround in current account balance, moderate inflation rate, correction in exchange rate and drop in nominal interest rate. How would these changes have an influence on agriculture?

The policy channel : The mechanisms through which changes in the macroeconomic variables are transmitted to agriculture are several. At a general level, macroeconomic imbalances reflected in the levels of fiscal and current account deficits are characterised by their composition as well. Lower fiscal deficit may be achieved by expenditure compression or revenue expansion. Lower imports or higher exports may achieve lower current account deficit. The manner in which imbalances are realised may also have an impact of its own. Besides these composition effects, the 'twin deficits' have an impact on aggregate prices: interest, inflation, and exchange rates. More importantly, the imbalances also lead to policy responses such as controls on credit availability, access to markets and quality of government services each of which affects all producers, including agriculture.

The investment channel : The market signals induced by macroeconomic changes have an impact on investment. Changes in interest and inflation rates affect real interest rate, which in turn influences investment decisions of farmers. Poor fiscal conditions also affect government spending on investment projects. In addition, inflation rate may also have an impact on terms of trade (price ratio) as changes in inflation rate may imply differential changes in sectoral price indices. In other words, there may be changes in the 'terms of trade' not only due to the changes in prices resulting from structural factors such as the changes in tariff rates but also due to differences in the speed with which different prices adjust to the macroeconomic shocks.

The exports channel : The third mechanism is the impact of changes in exchange rate on agricultural exports. Changes in real exchange rate influence the competitiveness of exports in general and

hence agricultural exports as well. Changes in the performance of exports influences total demand for farm output and hence overall agricultural output.

There are, thus, potentially individual or direct effects of changes in macroeconomic conditions on agriculture and these effects are further influenced by inter-relationships within agriculture. However, we should also point out that the macroeconomic variables themselves are inter-related and the impact of one change influences the others and the impact on agriculture is not limited to just the change in one factor. The Vector Auto Regressive method is a suitable econometric tool to analyse such inter-relationships.

The vector auto regression (VAR) representation of variables allows an assessment of the inter-relationship in a dynamic framework. Although this representation has often been termed 'a-theoretic', choice of the variables in the VAR can be guided by theory.

An unrestricted VAR model (Sims 1980) is written as follows:

$$y_t = c + A(L) y_t + e_t, \text{ where}$$

y_t is an $(n \times 1)$ vector containing each of the n variables included in the VAR;

$A(L)$ is an $(n \times n)$ polynomial matrix of co-efficient in the back-shift operator L with lag length p ,

$$\text{i.e., } A(L) = A_1 L + A_2 L^2 + \dots + A_p L^p ;$$

c is an $(n \times 1)$ vector of intercept terms; and

e_t is an $(n \times 1)$ vector of white noise error terms.

The VAR framework permits us to examine the 'impulse response functions' of one of the variables in the VAR to shocks in the other variables. In other words, we are able to assess the response of say agricultural investment to macroeconomic shocks in a VAR framework. However, in one of the approaches, the results of VAR analysis would be sensitive to the ordering of variables in the VAR. For example, if we have a VAR of three variables, viz., y_1, y_2 and y_3 then the results may vary if we specify VAR as (y_1, y_2, y_3) or (y_2, y_1, y_3) or (y_3, y_2, y_1) . To overcome the ambiguity, the 'generalised impulse response functions' have been developed (Pesaran and Shin, 1998).

The 'variance decomposition' of the VAR allows us to quantify the contribution of different variables in a VAR to the variability of a selected variable. For example, the contribution of macroeconomic

variables to the variance of agricultural investment provides an assessment of the impact of the macroeconomic factors on agriculture.

Before proceeding to estimate the impulse response functions and carrying out the variance decomposition analysis, we attempt an examination of causality relationship between macroeconomic and agricultural performance variables. The causality analysis is carried out within the framework of 'block causality' of variables in the VAR. The 'Granger Block Causality' tests allow an assessment of the strength of the transmission mechanisms.

We have examined the generalised impulse response functions and variance decomposition results of selected VARs that include agriculture related variables and the macroeconomic variables. The macroeconomic variables considered in the present analysis are:⁴

- i. (Gross fiscal deficit/ GDP at market prices)
- ii. (Current account balance/ GDP at market prices)
- iii. Inflation rate (annual percentage change in consumer price index for industrial workers CPI_IW)
- iv. Interest rate (PLRX: Minimum lending rate of IDBI and PLR of commercial banks)
- v. Real exchange rate (REER based on 36 country trade weighted bilateral rates)

The agricultural variables are:

- i. Agricultural investment (Gross fixed capital formation in constant prices)
- ii. Agricultural exports (in US\$)
- iii. Agricultural GDP (in constant prices)

Three alternative specifications of VARs are used for the analysis:

1. VAR based on (X, GFDC/GDP, CAB/GDP, INFL, PLRX, REER)
2. VAR based on (X, INFL, PLRX, REER)
3. VAR based on (X, GFDC/GDP)

Where X = agriculture variable, taken one at a time from the list of three noted above; GFD is the gross fiscal deficit of the central government; CAB is the current account balance, INFL is the annual inflation rate based on CPI_IW, PLRX is the interest rate and REER is the real effective exchange rate noted above.

Before proceeding with the analysis, we first examine the stationarity of the variables involved. For the VAR analysis it is necessary that we include only the stationary variables in the VAR. The results of ADF tests for unit roots are summarised in table A.1 in the annexure. The ADF tests suggest that we should include first differences of agricultural investment, agricultural exports and agricultural GDP in the VAR rather than their levels. Accordingly the VARs are specified.

For the estimation of VAR, it is also necessary to specify the length of the lags of variables to be included in the analysis. We have used the AIC criteria for determining the lag-length for the VARs.

Findings

Causality Tests :

Existence of a statistical causal relationship between the macroeconomic variables and agricultural variables provides a basis for assessment of the nature of the impact of macroeconomic factors on agriculture. We have carried out 'Granger block causality tests' on the existence of such a relationship between macroeconomic and agricultural performance variables. Five different macroeconomic variables have been chosen for the present analysis of the inter-relationship of agriculture and macro economy. In Table1, we present the results of causality tests on three different agriculture performance variables and selected sets of the macroeconomic variables.

Table 1. Tests of Block Causality

Block Causality from (selected macroeconomic variables)	Causality to	Test statistic \pm^2 and level of significance
(CAD, FISCDEF, CPI, REER, PLRX)	Agricultural GDP	19.88** (0.03)
(PLRX, CAD, FISCDEF, CPI, REER)	Agricultural Exports	15.31 (0.12)
(CAD, FISCDEF, CPI, REER)	Agricultural Exports	15.26** (0.05)
(CAD, PLRX, CPI, FISCDEF, REER)	Agricultural Investment (real GFCF)	13.41 (0.20)
(CAD, PLRX, CPI, REER)	Agricultural Investment (real GFCF)	11.88 (0.16)
(PLRX, CPI, REER)	Agricultural Investment (real GFCF)	11.38* (0.08)
(CAD, FISCDEF)	(PLR, CPI, REER)	19.11* (0.09)

Note: Data used for the period 1970-71 to 2000-01; Order of VAR=2; Test statistic is based on the log likelihood ratio test of the null hypothesis of no causality.

There is strong evidence of causality from macroeconomic variables to agricultural GDP. The null hypothesis of absence of such a relationship is rejected at 3 percent level of significance. However, the causality from macroeconomic variables to agricultural exports appears significant when we consider only a subset of the macroeconomic variables. When we drop fiscal deficit from among the macroeconomic variables, causality from macroeconomic factors to exports is significant at a level of probability less than 10 percent. A similar pattern emerges in the case of agricultural investment. When all the five macroeconomic variables are included, the causal relationship is not significant. When we drop fiscal deficit from among the relationship, the causal relationship is still not significant. However, when we drop CAB as well, causality from macroeconomic variables to agricultural investment turns out to be significant.

We have also examined the inter-relationship among the macroeconomic factors as this inter-relationship may influence the relationship between macro variables and agricultural variables. Results in Table 2 show that the macroeconomic imbalances reflected in the fiscal deficit of the Centre and CAB have significant impact on aggregate prices. Thus, the impact of the macroeconomic variables on agriculture is not only through the direct impact of the individual variables but also through the combined effect of different macroeconomic conditions. It is also possible that some of the individual effects may complement each other and some may have an offsetting impact.

The overall conclusion that can be made from the above results is that there appears to be significant impact of macroeconomic variables on agriculture. Although not all the selected variables influence each of the chosen agricultural performance indicators, a subset of the macro variables does influence agriculture significantly.

Impulse Response Functions:

VAR methodology provides an estimate of the impact of a shock in terms of change in one component of VAR on all the components over time. The impact is measured by the impulse response coefficients (Greene, 1997). We discuss below the results of the impulse response analysis. In each of the cases described below, the impact on agriculture is a result of a one-standard error increase in a macroeconomic variable using one estimated VAR at a time. Three different versions of VAR are estimated for each agricultural performance variable: VAR with five macroeconomic variables (5M-VAR), three macroeconomic variables (3M-VAR) and two

macroeconomic variables (2M-VAR). The three alternatives provide a range of results and also indicate the robustness of the findings.

Impulse response analysis provides an estimate of the impact of a shock over time beginning with the year (period) in which the shock is administered. For the purposes of the present analysis, we have presented the results over a 25-year period from the year of the shock. This helps us examine the pattern of the impact and also quantify the impact over a period of time. We note that although the initial shock to the system is in terms of one macroeconomic variable, in the years following the initial shock, the other macroeconomic variables respond to the initial shock and in turn influence the agricultural variable. Thus, the subsequent impact on an agricultural variable, after the initial year, comprises the impact of the initial shock, secondary impact from the other macroeconomic variables and the dynamics of the agricultural variable itself. In the discussion, we attribute the impact to the initial shock but it should be borne in mind that secondary influences are at work, besides the primary or initial shock.

Agricultural Investment and the Macro-economic Factors :

Figure A-1 in Appendix presents the estimated impact of the one-standard error shock of each macroeconomic factor (one at a time) on agricultural investment. Some general observations can be made from the impulse response patterns. First, the impact of GFD of the Centre and CAB lasts over a short period of time relative to the other shocks. The impact of shocks of interest rate, exchange rate and inflation rate continues even up to 25 years. Second, agricultural investment increases in the initial few years due to an increase in GFDC and PLRX before it eventually becomes negative, whereas in the remaining three cases, the impact of an increase in the macro-economic variable reduces the agricultural investment. The impulse responses are also summarised in Table 2 below for the impact in the year 1 of the shock (Year 1 in the table), in two subsequent years and cumulative impact for 5, 10 and 25 years.

The initial positive impact on agricultural investment due to an increase in the nominal interest rate (PLRX) is counter-intuitive. However, one explanation for the result may be that, historically, there would be lead-lag relationship between the nominal interest rate variable chosen here (PLRX) and the interest rate relevant for agricultural investment. This also implies the possibility of a shift in investment from non-agricultural sectors to agriculture as the interest rate change affects non-agricultural sectors first. As time passes, the interest rate applicable for agricultural

investment would also increase and hence agricultural investment witnesses a decline.

Table 2. Results from Generalised Impulse Response Analysis: Impact of Macroeconomic Shocks on Agricultural Investment*

Item	Year1	Year2	Year3	Cumulative Impact		
				5 yrs	10yrs	25 yrs
5-MVAR+						
GFDC	26.0	-20.1	137.0	127.4	-4.0	-250.8
CAB	-96.2	-124.9	-301.3	-524.5	-682.4	-1035.0
REER	-83.9	-178.0	-393.5	-969.0	-1783.9	-3517.8
CPI_IW	-240.3	-435.4	-413.3	-1636.6	-2929.7	-5651.4
PLRX	105.2	-145.8	-169.2	-544.7	-1200.4	-2620.7
3-MVAR+						
REER	-64.9	-161.6	-315.7	-915.8	-1748.6	-3463.1
CPI_IW	-213.0	-424.7	-258.8	-1218.0	-2156.9	-3993.2
PLRX	116.0	45.7	-121.6	29.6	-58.8	-247.1
2-MVAR+						
GFDC	76.0	-9.6	152.2	374.2	694.7	1352.6
CAB	-28.0	-22.0	-265.9	-529.2	-1039.2	-2032.3

*measured in crores of rupees at constant prices.

+ M Stands for Macroeconomic Variables

The positive impact of a rise in GFDC in the initial few years suggests that the agricultural sector initially benefits from the demand-side effects of higher government expenditure. Some of these higher expenditures may also support input use in agriculture. However, over time, the effect turns negative.

Increase in the inflation rate (CPI_IW) has an adverse effect on agricultural investment. Although higher inflation resulting from crop failures may lead to higher crop prices and improved terms of trade, crop failures also decrease the farmer's ability to borrow and invest. The net impact of inflation on agricultural investment even in such cases is shown here to be adverse.

Improvement in CAB has an adverse impact on agricultural investment. A lower CAD (or higher CAB) leading to an appreciating rupee may imply lower benefits from exports and slow-down in agricultural investment driven by export demand for agricultural products. This impact is consistent with the impact of an exchange rate shock to the VAR. A rise in the real value of the rupee (rise in REER) leads to a decline in agricultural investment.

We have attempted to examine the 'robustness' of the results by using smaller number of macro-economic variables in the VAR. Table 3,4 and 5 provide the pattern of impulse responses when the VAR includes only PLRX, REER and CPI_IW; and GFDC and CAB variables respectively. The results are more or less similar in both the cases to those obtained when all the five macro-economic variables are introduced in the VAR (see 5, 10 and 25 years cumulative impacts). However, in the case of GFDC, when we use the 2M-VAR, the impact on agricultural investment remains positive over the entire period of 25 years.

Agricultural Exports and Macro-economic Factors:

The impulse responses of agricultural exports, presented in Figure A-2 in the Appendix, to macroeconomic factors show a fluctuating pattern relative to the case of agricultural investment shown earlier. The initial (first period) impact on agricultural exports is positive for an increase in exchange rate (REER), inflation rate (CPI_IW) and interest rate (PLRX). In the later period, there is larger negative impact, although the impact is not uniform over time. The pattern is similar for the REER and CPI_IW shocks. The impulse response is summarised in Table 3 below for agricultural exports also (Figure A-2 in Appendix).

The initial positive impact is likely to be due to the slower adjustment of export prices of agriculture in response to the changes in exchange rate. The fluctuating pattern, however, suggests that the response to macroeconomic changes may be influenced by other factors as well.

An explanation for the initial positive impact of higher inflation rate on agricultural exports again may lie in the differences in the export basket relative to the domestic consumption basket.

Table 3. Results from Generalised Impulse Response Analysis: Impact of Macroeconomic Shocks on Agricultural Exports*

Item	Year1	Year2	Year3	Cumulative Impact		
				5 yrs	10yrs	25 yrs
5-MVAR						
GFDC	-103.7	-43.3	86.2	-156.5	-70.0	-79.1
CAB	-108.9	43.8	157.9	89.6	4.9	1.8
REER	158.8	65.4	-274.8	45.2	51.8	65.7
CPI_IW	161.9	-165.4	59.9	132.1	111.1	111.9
PLRX	32.6	-68.0	71.9	111.9	67.3	70.3
3-MVAR						
REER	54.0	-27.9	-31.1	9.0	6.6	5.9
CPI_IW	49.0	-41.7	4.1	35.8	27.8	27.6
PLRX	53.5	-48.2	-12.2	12.7	10.8	10.8
2-MVAR						
GFDC	-21.2	-67.0	115.0	-73.2	-5.7	-4.3
CAB	1.6	-13.9	134.5	63.2	31.5	35.8

* measured in U S million dollars

The initial *positive* response of agricultural exports to interest rate increase is relatively much smaller than the response to exchange and inflation rates. The credit negotiated for exports may be at a fixed rate of interest and the terms may not change for all exports as soon as the PLR of the banks changes. However, we do observe a negative response thereafter. The initial positive response may also reflect a past pattern in which higher interest rates have followed higher inflation rates and they have also accompanied pressures on balance of payment and hence policies to increase exports.

GFDC and CAB have adverse impacts on agricultural exports in the initial year of the shock. As GFDC increases, agricultural exports decrease initially and then see a fluctuating pattern. As CAB improves, agricultural exports see a decrease initially. Rise in fiscal deficit may influence agricultural exports initially as higher fiscal deficit may imply

higher domestic demand relative to exports. The adverse impact of improved CAB may arise from relatively reduced policy pressures to increase exports.

3M-VAR and 2M-VAR including agricultural exports as the agriculture performance variable confirm the pattern of impulse response seen in the 5M-VAR (Table 3).

Agricultural GDP and Macroeconomic Factors :

The overall performance measure for agriculture selected in this analysis is agricultural GDP. Impact of macroeconomic shocks on agricultural GDP captured in the impulse responses is spread over relatively short periods of time (Figure A-3 in the Appendix). We observe that increase in fiscal deficit initially has a negative impact on agricultural GDP. Earlier we found that fiscal deficit impacts positively on investment in the initial period. Increase in investment may give rise to higher output, which in turn may reduce agricultural prices. Reduction in price in turn may produce a negative impact on agricultural GDP. The initial impact is significant and negative for an increase in inflation rate and increase in interest rate. In the case of exchange rate, GFDC and CAB, the initial impact is small. In all the cases, subsequent impact is greater than the initial impact. The results are summarised in Table 4.

Higher rate of inflation is usually accompanied by poor agricultural output. This in turn may adversely affect the income of the farmers for that year and hence their investment capabilities. The adverse effect on output in the next year would thus be a result of this phenomenon. This pattern is captured in the immediate adverse impact of higher inflation rate on agricultural GDP. The adverse impact of higher interest rate on agricultural GDP may also reflect the same pattern of impact as higher inflation and higher interest rates coincide with poor agricultural output.

When the impulse responses are examined with fewer macroeconomic factors in the VAR, the results are broadly consistent with the results from the 5-MVAR. However, the initial impact of REER is positive and greater on agricultural GDP and the initial impact of a rise in CAB and GFDC is adverse and noticeable on agricultural GDP when there are fewer macro-economic variables in the VAR (Table 4).

**Table 4. Results from Generalised Impulse Response Analysis:
Impact of Macroeconomic Shocks on Agricultural GDP***

Item	Year1	Year2	Year3	Cumulative Impact		
				5 yrs	10yrs	25 yrs
5-MVAR						
GFDC	-209.2	-3272.0	-2067.4	-2977.6	-3977.0	-4019.1
CAB	42.7	1993.3	1288.0	1378.5	2987.2	2901.6
REER	-162.1	1925.5	-757.9	1570.7	1854.1	2133.8
CPI_IW	-4335.7	5166.3	-1498.3	-2507.3	-2865.0	-3051.6
PLRX	-3164.1	3494.2	-1659.3	-3683.2	-3863.2	-4197.7
3-MVAR						
REER	1828.9	104.7	-213.5	1434.2	1463.4	1460.3
CPI_IW	-2652.2	4093.9	-1198.6	60.9	154.7	152.8
PLRX	-4517.1	3056.3	-1177.3	-2136.0	-2085.0	-2086.4
2-MVAR						
GFDC	-700.7	-2191.6	-2152.8	-2618.5	-2850.7	-2871.3
CAB	-786.0	2123.6	409.9	549.4	843.2	857.8

* measured in crores of rupees at constant prices

Integrated View of the Results:

Results from three different specifications of the VARs show that the impact of different macroeconomic factors on the three selected agricultural performance variables is not the same. For example, an appreciation of REER is seen to affect agricultural exports and agricultural investment differently. To provide an integrated view of the results, we summarise in Table 5 the estimated impact from the 5M-VAR as this VAR captures a greater variety of direct and indirect linkages between agriculture and macroeconomic factors:

Table 5. Impact of the Macroeconomic Factors on Agriculture: Results from 5M-VAR (Cumulative Impulse Response over 25 Year Period)

Macroeconomic variable	Agricultural GDP	Agricultural exports	Agricultural investment
GFDC	Negative	Negative	Negative
CAB	Positive	Positive	Negative
PLR*	Negative	Positive	Negative
REER	Positive	Positive	Negative
INFL_IW	Negative	Positive	Negative

Note: The results that are different from the remaining two cells across the row are in bold font.

Along with some expected linkages, the results also present some counter-intuitive implications of changes in the macroeconomic conditions. However, some of the expected linkages are also present, e.g. rising fiscal deficit at the Centre appears to have an adverse impact on agriculture, be it GDP, exports or investment. Improvement in CAB has a positive impact on GDP. Higher interest rate has a negative impact on GDP and investment. An appreciating rupee has a positive impact on GDP.

Although the VAR results present a 'reduced form' type of impact and, therefore, do not represent structural relationships, some of the estimated impacts are surprising if viewed as a structural relationship: Improvement in CAB has a negative impact on investment; Higher PLRX has a positive impact on exports; the appreciating rupee has a negative impact on investment; or, higher inflation increases agricultural exports. We have attempted to provide a plausible set of explanations for these counter-intuitive findings in the discussion above.

Clearly, it is difficult to identify structural relationships through VARs. But the results presented above show that the macroeconomic factors do influence agriculture through a number of interfaces. Thus, the agricultural sector is not immune to macroeconomic policy changes as generally perceived.

The Variance Decomposition :

VAR methodology presents a means of assessing the contribution of different variables in a system to changes in any given variable within the VAR. The 'variance decomposition' component provides an estimate of the contribution of a variable to the variability of another variable in

the VAR. We apply this variance decomposition technique to assess the contribution of the macroeconomic variables to variability in the selected agricultural variables. Table 6 summarises the results of the variance decomposition analysis. For each of the three agricultural variables, we have used VARs comprising three alternative sets of macro-economic factors: 5M-VAR, 3M-VAR and 2M-VAR⁵.

The results indicate that the macroeconomic factors are important in explaining the variability in agricultural performance indicators. The macroeconomic factors in different VARs also point to the fact that the 'price' variables are significant in explaining the variability in the case of agricultural GDP and agricultural investment but not in explaining agricultural exports. The macro imbalances are significant in explaining all the three agricultural performance indicators.

The 5M-VAR results shows that 40–50% of variability in agricultural performance indicators is captured by the macro-level factors. This is a strikingly significant impact and indicates that agricultural sector is not insulated from the overall macroeconomic conditions of the economy.

Table 6. The Impact of Macroeconomic Factors on Agriculture: Percentage of Variance in Agricultural Performance Variables Explained by Macro-economic Factors

Item	GFDC	CAB	CPI_IW	REER	PLRX	Total
Agricultural GDP						
5MVAR	9.41	2.30	23.00	4.70	9.84	49.25
3MVAR	-	-	15.22	2.54	16.29	34.05
2MVAR	10.76	4.47	-	-	-	15.23
Agricultural Exports						
5MVAR	11.46	10.76	11.03	21.36	1.13	55.74
3MVAR	-	-	1.09	0.94	1.65	3.68
2MVAR	10.55	13.84	-	-	-	24.39
Agricultural Investment						
5MVAR	0.77	2.97	24.54	8.61	4.98	41.87
3MVAR	-	-	17.67	8.71	1.16	27.54
2MVAR	2.07	3.12	-	-	-	5.19

Concluding Remarks

In this paper, we set out to assess the impact of macroeconomic factors on agriculture using the time-series approach. There are clearly several mechanisms by which the shocks to macroeconomic variables would be transmitted to decision variables in agriculture and finally affect the performance of the sector. For the purposes of the present analysis, two sets of macroeconomic variables were selected. The price variables, viz., exchange rate, inflation rate and interest rate form one set and the macro imbalances, viz., the ratio of gross fiscal deficit of the centre to GDP at market prices and that of current account balance to GDP at market prices. We also chose three agriculture-related variables: agricultural investment (real), agricultural exports (US\$) and real agricultural GDP for measuring the sensitivity of agricultural sector to the macroeconomic conditions.

Causality tests show that the agricultural sector is influenced by macroeconomic conditions. Although the specific macroeconomic factors influencing each agricultural variable may differ, a relationship between macroeconomic conditions and agricultural performance exists.

Results of impulse response analysis capture the direction of the impact of macroeconomic shocks to agriculture. The impact of macroeconomic imbalances is found to be relatively short term whereas the impact of price changes is spread over a long period. The direction of the impact is not always along the 'expected lines' indicated by structural relationships, suggesting significant inter-relationships of variables.

Variance decomposition analysis suggests that macroeconomic factors may contribute 40—50% of the variance of the various agriculture-related variables. As more macroeconomic factors are considered, their contribution to the variability of agricultural variables increased.

The present analysis has pointed to the substantial impact of macroeconomic factors on agriculture. The analysis does not fully track all the transmission mechanisms but is suggestive of the likely links. While the results need to be qualified by the underlying assumptions, it is difficult to ignore the need to keep in view the changes in the macroeconomic factors to understand the changes in the agricultural sector.

Notes

¹Greene (1997) and Enders (1995) provide detailed discussions of the theory as well as applications.

²Inflation rate is based on Consumer Price Index for Industrial Workers (CPI_IW), real exchange rate (REER) is based on 36 country trade weighted index, interest rate is the Minimum Lending Rate of IDBI up to 1993-94 and PLR of the major commercial banks since then.

³This points to the role of global factors in influencing agricultural exports. Therefore, it is not the domestic macroeconomic conditions alone that affect the agricultural exports.

⁴All the data are from Reserve Bank of India, Handbook of Statistics on Indian Economy, 2002-03 and Economic Research Foundation, 2002.

⁵We have used Cholesky decomposition for this analysis using an ordering of the variables in the VAR that give impulse response results similar to those from the generalised impulse response approach.

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Appendix

Table A.1 Unit Root Tests of Selected Variables

Variable	ADF Statistic for Variable in						Order of Integration
	Level form lag1	Level form lag2	First Difference form lag1	First Difference form lag2	Second Difference form lag1	Second Difference form lag2	
CPI_IW	-0.751 (DW 2.011)	-0.887 (DW 2.003)	-2.972 (DW 1.961)	-2.221 (DW 1.989)	-6.102*** (DW 2.132)	-4.586*** (DW 1.821)	I(2)
REER	-1.510 (DW 1.936)	-1.254 (DW 1.818)	-3.886** (DW 1.836)	-3.037 (DW 1.451)			I(1)
PLR	-1.112 (DW 2.008)	-0.687 (DW 2.097)	-4.916*** (DW 2.143)	-4.431*** (DW 1.938)			I(1)
GDP_AGR	-2.618 (DW 2.086)	-1.947 (DW 1.941)	-5.816*** (DW 1.980)	-3.799** (DW 1.957)			I(1)
AGR_EXPORTS	-1.623 (DW 1.552)	-1.463 (DW 1.546)	-2.1792 (DW 1.563)	-1.508 (DW 1.635)	-4.303 ** (DW 1.871)	-4.026** (DW 1.908)	I(2)
GFCF_AGR	-1.797 (DW 1.852)	-2.055 (DW 2.030)	-3.748** (DW 1.970)	-3.061 (DW 1.984)			I(1)
FISDEF/GDP	-1.372 (DW 2.028)	-0.814 (DW 1.882)	-5.298*** (DW 1.925)	-4.308*** (DW 2.018)		I(1)	
CAB/GDP	-1.79 (DW 1.941)	-1.447 (DW 1.753)	-4.961*** (DW 1.855)	-4.745*** (DW 1.626)			I(1)

FIGURE A-1. Impulse Response Analysis for Agricultural Investment

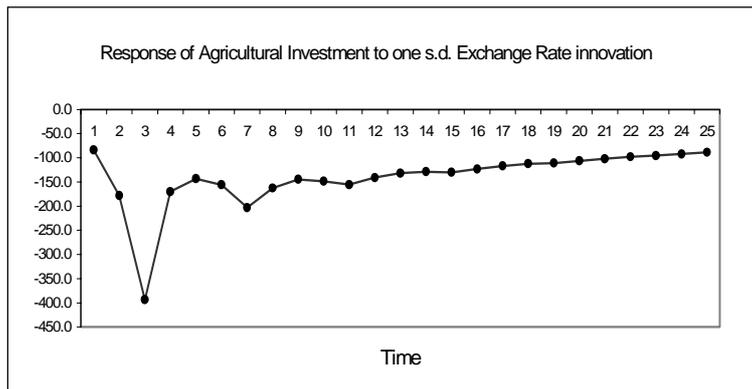
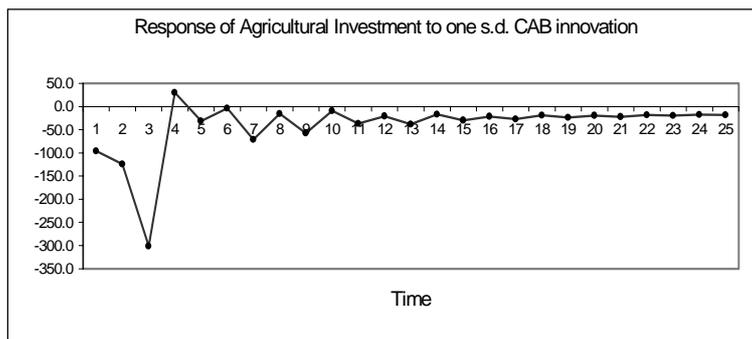
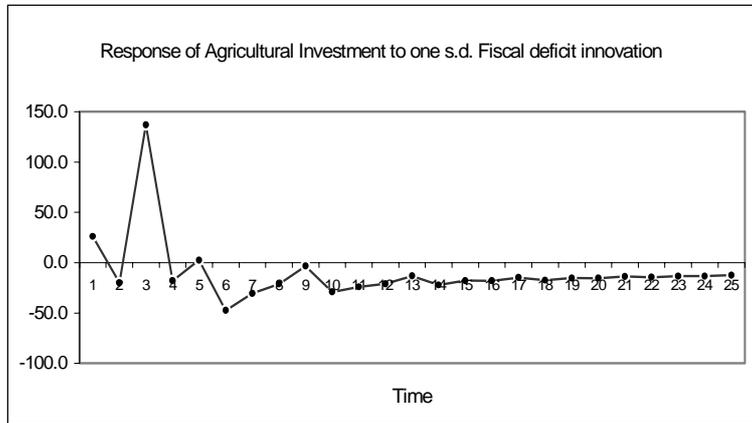


FIGURE A-1 (continued)

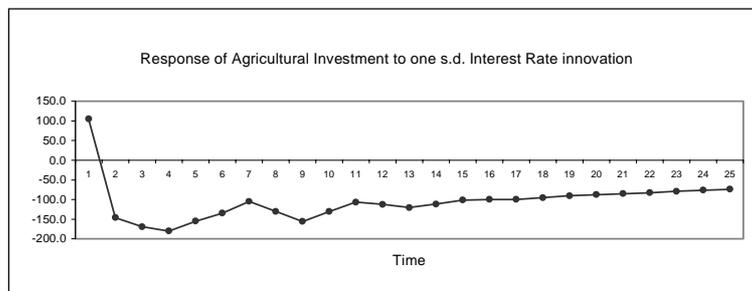
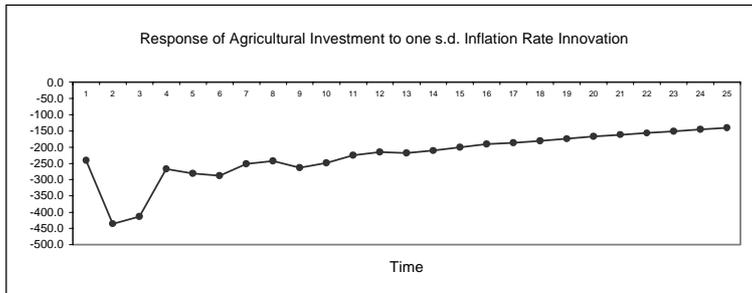


FIGURE A-2. Impulse Response Analysis for Agricultural Exports

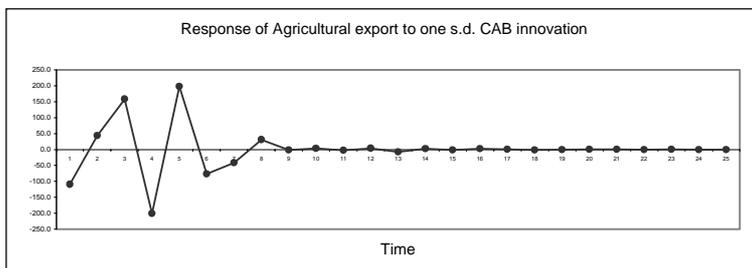
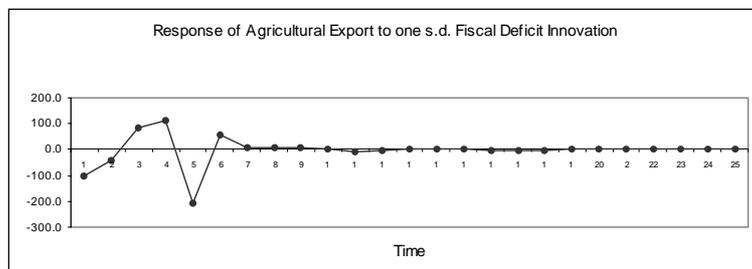


FIGURE A-2 (continued)

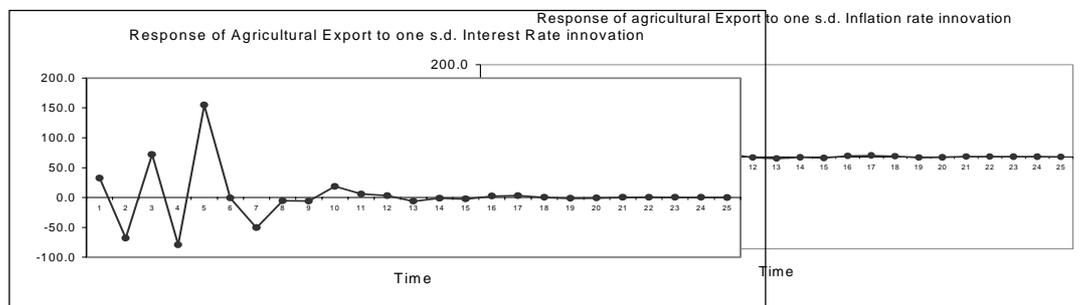
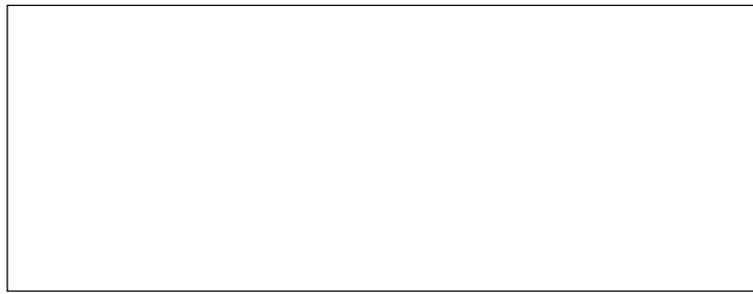
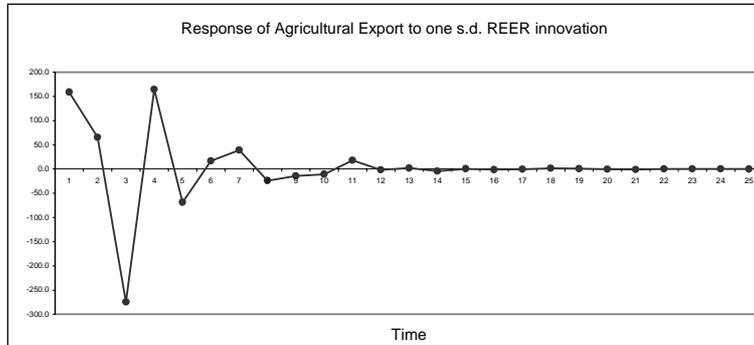


FIGURE A-3. Impulse Response Analysis for Agricultural GDP

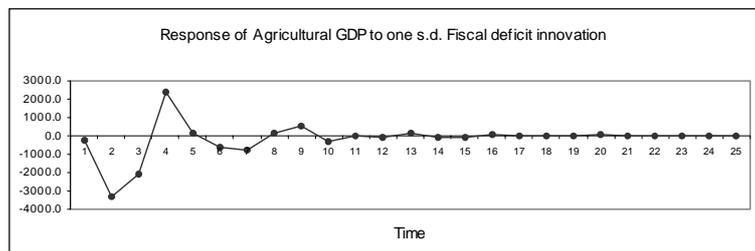


FIGURE A-3 (continued)

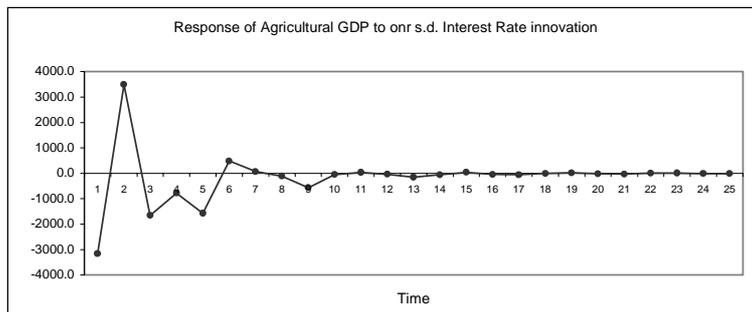
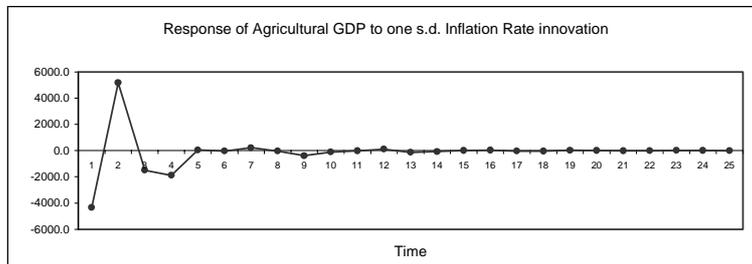
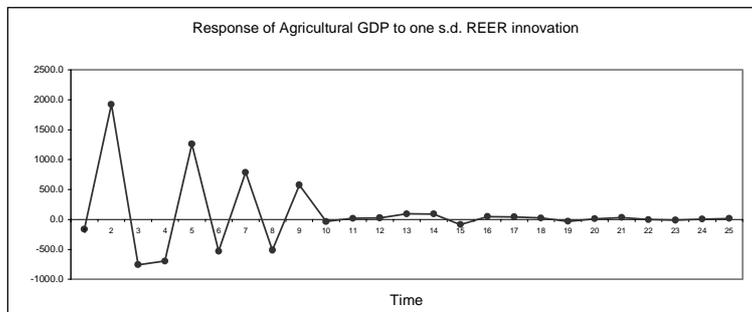
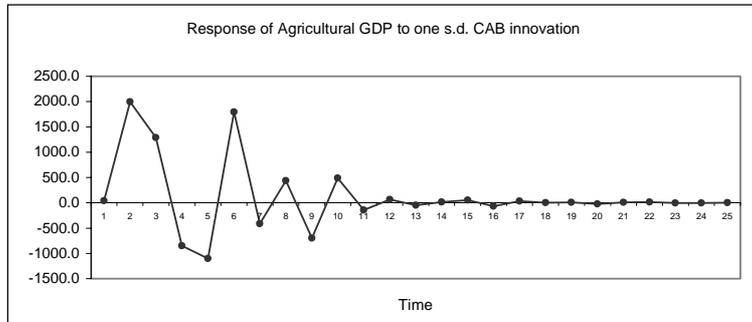


Table A .2 Basic Data Used in the Study

Year	Agri-cultural Exports (US \$ mill)	Agri-cultural GDP (Rs.crores in 1993-94 prices)	Investment in Agriculture (Rs.crores in 1993-94 prices)	Current Account Balance (as a % of GDP at market prices)	Fiscal deficit (as a % of GDP at market prices)	Prime Lending Rate	Real Effective Exchange Rate	Consumer Price Index for Industrial Workers
1970-71	589.1	137320.0	7902.00	-0.97	3.08	8.5	125.36	-
1971-72	643.7	134742.0	8349.00	-1.02	3.53	8.5	121.78	3.23
1972-73	774.4	127980.0	8831.00	-0.58	4.04	8.5	119.56	7.81
1973-74	962.2	137197.0	8760.00	1.73	2.64	9.0	127.50	20.77
1974-75	1387.1	135107.0	8212.00	-1.23	2.97	10.3	114.14	26.80
1975-76	1556.5	152522.0	8924.00	-0.21	3.64	11.0	106.27	-1.26
1976-77	1563.4	143709.0	11066.00	1.00	4.24	11.0	101.34	-3.83
1977-78	1948.0	158132.0	11347.00	1.11	3.62	11.0	100.12	7.64
1978-79	1902.0	161773.0	12780.00	-0.22	5.18	11.0	91.98	2.16
1979-80	2246.4	141107.0	13344.00	-0.46	5.29	11.0	97.08	8.76
1980-81	2334.6	159293.0	13721.00	-1.54	5.77	14.0	104.48	11.39
1981-82	2403.5	167723.0	13407.00	-1.68	5.14	14.0	104.48	12.47
1982-83	2220.0	166577.0	13766.00	-1.74	5.64	14.0	101.17	7.76
1983-84	2174.6	182498.0	13926.00	-1.51	5.94	14.0	104.24	12.55
1984-85	2205.3	185186.0	13846.00	-1.17	7.09	14.0	100.86	6.31
1985-86	2190.4	186570.0	13061.00	-2.14	7.86	14.0	98.27	6.78
1986-87	2323.4	185363.0	12789.00	-1.87	8.47	14.0	90.24	8.73
1987-88	2560.7	182899.0	13375.00	-1.78	7.63	14.0	85.36	8.76
1988-89	2417.3	211184.0	14335.00	-2.75	7.34	14.0	80.41	9.40
1989-90	2852.7	214315.0	12728.00	-2.34	7.33	14.0	78.44	6.13
1990-91	3354.4	223114.0	15805.00	-3.05	7.85	14.5	75.58	11.56
1991-92	3202.5	219660.0	14546.00	-0.34	5.56	19.0	64.20	13.47
1992-93	3135.8	232386.0	15610.00	-1.71	5.37	18.0	57.08	9.59
1993-94	4027.5	241967.0	14749.00	-0.42	7.01	16.0	61.59	7.50
1994-95	4226.1	254090.0	15978.00	-1.05	5.70	15.0	66.04	10.08
1995-96	6081.9	251892.0	16824.00	-1.65	5.07	16.5	63.62	10.21
1996-97	6862.7	276091.0	17009.00	-1.19	4.88	14.8	63.81	9.27
1997-98	6626.2	269383.0	17046.00	-1.37	5.84	14.0	67.02	7.02
1998-99	6034.5	286094.0	17730.00	-0.95	6.45	12.5	63.44	13.11
1999-00	5608.0	286983.0	17543.00	-1.04	5.35	12.3	63.29	3.38
2000-01	5973.2	285877.0	17982.00	-0.54	5.32	11.5	66.53	3.74