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A re-look at sectoral linkages in more recent Indian data

Manas Paul
Axis Bank Ltd
manas.paul@axisbank.com

Abstract

Understanding inter-sectoral linkages helps in developing a better perspective about possible feedback mechanisms that might exist across sectors. This can be of importance in assigning appropriate policy priority to sectors whose growth feeds into other sectors as well. It is in this respect that we examine the direction of causality in a systems framework across agriculture, industry and services sector of Indian economy using quarterly data between Q21997 to Q32009. Causality tests in a systems framework as proposed by Sargent (1976) could not reject the presence of bi-directional causality between industry and services sector growth. Moreover, in a system of higher order VAR we find uni-directional causality running from both industry and services sector to growth in agriculture. Contrary to popular notion we find no evidence of directional causality running from agriculture either to industrial or to services sector growth. Even Impulse response functions of different orders of VAR downplay the importance of agriculture in feeding into non-agricultural growth. Though impulse responses in a system of lower order VAR supports the importance of a relatively stronger feedback mechanism running from services sector to both industry and agriculture. The results appear to be in support of near-term policy initiatives favoring the industrial and more so the services sector in sustaining the growth momentum of the economy especially during periods of exogenous agricultural shocks.

Author Keywords: Agriculture; Industry; Indian economy; causality, impulse response

JEL Classification:

1. Introduction:

A large part of the credit behind the current phase of phenomenal Indian growth has been attributed to the structural reforms that got initiated in early 1990's. The changes associated with such reforms are likely to get captured in the more recent data than those lying further off. It was in this respect that we thought of exploring the sectoral inter-linkages in Indian economy using the more recent quarterly data on Indian GDP, (available from 1996 onwards).

The structural reforms so far, have been perceived to be more successful in increasing the efficiency and competitiveness of Indian industry largely comprised of manufacturing. Impacts of agricultural reforms that have been perused so far are either perceived to be inadequate or at least far from being as far reaching as they have been for manufacturing.

Exogenous shocks to economy through agriculture as a fall-out of adverse weather conditions remains a reality even today. In such an event, the presence of bi-directional sectoral linkages between industry and services (in the absence of directional causality running from agriculture to non-agriculture growth) can still help sustaining the growth momentum through appropriate policy initiatives favoring these sectors. Policy initiatives favoring industry and services in such a set up would be effective in neutralizing some of the negatives of adverse shocks from agriculture. In the same spirit adverse shocks either to industrial and/or services growths are likely to get magnified and policy initiatives directed towards agriculture alone to counter this need not be effective in yielding the desired result.

Given the importance of this issue, it is unlikely that it has not been explored before in the Indian context. Kalirajan & Shanker (2001), while discussing the subdued importance of agriculture in India's economic reform program, pointed towards bi-directional causality between industrial performance and agriculture. Chaudhuri & Rao (2004) in a cointegrating analysis framework pointed out that the presence of exogeneity of agriculture and endogeneity of industrial performance in an industry agriculture inter-linkage need not be taken for granted. In other words agriculture need not be the driving force in an industry agriculture inter-linkage. Tarlok Singh (2009), emphasizes the importance of services sector in supporting Indian growth.

All of these studies are based upon long-term annual data that either club together periods before and after the structural reforms or deals with pre-reform period data. Moreover, these studies end up adopting a two variable framework approach in exploring either the inter-linkage between industry and agriculture or between services GDP and non-services GDP. We wanted to take a fresh look at the sectoral inter-linkages in the more recent Indian data. Given the data is of a much shorter period unlike Chaudhuri & Rao (2004) or Tarlok Singh (2009), we do not look for any long-term relationship in the data. We restrict ourselves to causality analysis. However, one, unlike Kalirajan & Shanker (2001), instead of a single equation framework, we explore the causality in a systems equation framework as suggested by Sargent (1976) and two instead of a two variable framework we do allow for the explicit interplay of all the three components of GDP – the agriculture, industry and the services, allowing simultaneous variance in them.

2. Methodology:

The study is based upon quarterly the data on the three broad sectors of GDP: (i) Industry (ii) Agriculture & (iii) Service from Q21997 to Q32009. In our analysis agricultural growth (AGR) implies growth of output from agriculture and allied activities (like forestry & fishing). Industrial growth (IND2) means growth in the sum total of output from (i) mining & quarrying (ii) manufacturing & (iii) Electricity gas and water supply. Services growth (SERV2) implies the growth in sum total of output from (i) Construction (ii) Trade, hotels, transport & communication (iii) financing, insurance, real estate and business services. The data source is National Accounts Statistics from the Central Statistical Organisation. The classification of overall sectors (of agriculture, industry and services) is as per RBI (Reserve Bank of India) data as presented in the Hand Book of Statistics on Indian Economy.

As a first step we look into the order of integration of the individual series. We use ADF tests to determine the order of integration of the variables.

Table 1. ADF test statistics

Variable	Model	Test statistics	Model selected lags
AGR	Constant without trend	-3.17*	04
IND2GR	Constant without trend	-2.62 **	01
SERV2GR	Constant & trend	-5.813853 *	00

** significant at 10% level
* significant at less than 5% level

The ADF statistics points to the absence of unit roots in these variables, indicating the variables to be I(0). On the presumption of these variables being 1(0), we resort to exploring causality amongst them in a systems framework vide Sargent (1976).

The perception of 'Causality' is based upon the idea that a cause cannot come after the effect. If a variable x affects a variable y then it should help improving the predictions of the latter variable. Granger's (1969) concept of causality was based upon prediction error:

" x 'causes' z if and only if z_t is better predicted by using the past history of x than by not doing so with the past of z being used in either case." (Guilkey and Salemi, 1982, pg.669).

This definition of causality or 'Granger causality' though purely statistical in nature has wide acceptance due to its intuitive appeal. Several tests have been developed to put this concept of 'Granger causality' into practice. Among the eight alternative causality tests that Geweke *et. al*. (1983) compare, they conclude that their modified version of a test originally proposed by Sims (1972) and a test proposed by Sargent (1976) outperform other tests in Monte-Carlo experiments. Guilkey and Salemi (1982) show that of these two, the causality test developed by Sargent (1976) is to be preferred where degrees of freedom are limited. Since our analysis is based on just above twelve years of quarterly data we use Sargent's test in a Vector Auto Regression (VAR) framework.

The systems framework helps to avoid the problem of simultaneity that might obstruct results of simple Granger-causality analysis. The only decision that should be made beforehand concerns the number of variables to be considered in their causal relationship, without imposing any a priori identifying conditions from economic theory.

The Granger-causality test proposed by Sargent (1976) starts from the following VAR model of order p :

$$\begin{pmatrix} x_{1t} \\ . \\ . \\ x_{it} \\ . \\ . \\ x_{nt} \end{pmatrix} = \begin{bmatrix} \Psi_{11}(L)......\Psi_{1j}(L)......\Psi_{1n}(L) \\ . \\ . \\ \Psi_{i1}(L)......\Psi_{ij}(L).....\Psi_{in}(L) \\ . \\ . \\ \Psi_{n1}(L).......\Psi_{nj}(L).....\Psi_{nn}(L) \end{bmatrix} \begin{pmatrix} x_{1t} \\ . \\ . \\ x_{jt} \\ . \\ . \\ x_{nt} \end{pmatrix} + \begin{pmatrix} \varepsilon_{1t} \\ . \\ . \\ \varepsilon_{jt} \\ . \\ . \\ \varepsilon_{nt} \end{pmatrix}$$

where $\Psi_{ij}(L) = (\psi_{ij1}L + \psi_{ij2}L^2 + ... + \psi_{ijp}L^p)$, L is the lag operator such that $Lx_t = x_{t-1}$, and ε_{it} are zero mean white noise innovations with constant covariance matrix $\sum = E(e_{jt}e_{kt})$ and not necessarily zero for $j \neq k$. In this n-equation model, x_j does not Granger cause x_i if and only if all the coefficients of $\Psi_{ij}(L)$ are zero.

As the next step towards estimating the VAR system, we needed to select the lag length of the VAR. Allowing for sufficiently long lags (of seven to nine lags) different lag selection criterion presented below selects VAR of either one period or four period lags.

Table 2: Lag-length selection criteria for the VAR

Lag	LR	FPE	AIC	SC	HQ
0	NA	668.0417	15.01796	15.14083	15.06327
1	74.92	148.92	13.52	14.00*	13.69*
2	13.45	156.88	13.56	14.42	13.88
3	12.66	165.31	13.60	14.82	14.05
4	24.15*	116.04*	13.20*	14.81	13.80
5	11.29	122.55	13.21	15.18	13.93
6	4.81	165.74	13.43	15.76	14.29
7	4.87	226.07	13.61	16.32	14.61

LR: sequential modified LR test statistic (each test at 5% level); FPE: Final prediction error; AIC: Akaike information criterion; SC: Schwarz information criterion; HQ: Hannan-Quinn information criterion

The VAR system selected by the different criteria reported above would be of either of the following form:

AGR = C(1)*AGR(-1) + C(2)*IND2(-1) + C(3)*SERV2(-1) + C(4) + ε_{AGRt}

IND2 = C(5)*AGR(-1) + C(6)*IND2(-1) + C(7)*SERV2(-1) + C(8) + $\varepsilon_{IND2GRt}$

SERV2 = C(9)*AGR(-1) + C(10)*IND2(-1) + C(11)*SERV2(-1) + C(12) + $\varepsilon_{3SERV2GRt}$

Or

AGR = C(1)*AGR(-1) + C(2)*AGR(-2) + C(3)*AGR(-3) + C(4)*AGR(-4) + C(5)*IND2(-1) + C(6)*IND2(-2) + C(7)*IND2(-3) + C(8)*IND2(-4) + C(9)*SERV2(-1) + C(10)*SERV2(-2) + C(11)*SERV2(-3) + C(12)*SERV2(-4) + C(13) + ε_{AGRt}

IND2 = C(14)*AGR(-1) + C(15)*AGR(-2) + C(16)*AGR(-3) + C(17)*AGR(-4) + C(18)*IND2(-1) + C(19)*IND2(-2) + C(20)*IND2(-3) + C(21)*IND2(-4) + C(22)*SERV2(-1) + C(23)*SERV2(-2) + C(24)*SERV2(-3) + C(25)*SERV2(-4) + C(26) + $\varepsilon_{IND2GRt}$

SERV2 = C(27)*AGR(-1) + C(28)*AGR(-2) + C(29)*AGR(-3) + C(30)*AGR(-4) + C(31)*IND2(-1) + C(32)*IND2(-2) + C(33)*IND2(-3) + C(34)*IND2(-4) + C(35)*SERV2(-1) + C(36)*SERV2(-2) + C(37)*SERV2(-3) + C(38)*SERV2(-4) + C(39) + $\varepsilon_{3SERV2GRt}$

Employing the seemingly unrelated regression (SURE) framework we estimate the above system of VAR(1) & VAR(4) and arrive at the causality tests by testing the wald statistics for the respective restrictions.

Table 3: Results of causality test in VAR(1) system of equations

Null Hypothesis	Coefficient restriction in the system	X^2-test statistic	P-value	Conclusion
IND2 does not Granger cause AGR	C(2)=0	1.03	0.3101	Do not reject
SERV2 does not Granger cause AGR	C(3)=0	1.69	0.1926	Do not reject
AGR does not Granger cause IND2	C(5)=0	1.01	0.3156	Do not reject
SERV2 does not Granger cause IND2	C(7)=0	2.70 **	0.0999	**Reject**
AGR does not Granger cause SERV	C(9)=0	0.24	0.6226	Do not reject
IND2 does not Granger cause SERV2	C(10)=0	3.18 **	0.0742	**Reject**

** Significant at 10% level of significance;

Table 4: Results of causality test in VAR(4) system of equations

Null Hypothesis	Coefficient restriction in the system	X^2-test statistic	P-value	Conclusion
IND2 does not Granger cause AGR	C(5)=0, C(6)=0, C(7)=0, C(8)=0	15.20	0.0043	**Reject**
SERV2 does not Granger cause AGR	C(9)=0, C(10)=0, C(11)=0, C(12)=0	9.91	0.0419	**Reject**
AGR does not Granger cause IND2	C(14)=0, C(15)=0, C(16)=0, C(17)=0	3.64	0.4556	Do not reject
SERV2 does not Granger cause IND2	C(22)=0, C(23)=0, C(24)=0, C(25)=0	7.87	0.0961	**Reject**
AGR does not Granger cause SERV	C(27)=0, C(28)=0, C(29)=0, C(30)=0	2.78	0.5953	Do not reject
IND2 does not Granger cause SERV2	C(31)=0, C(32)=0, C(33)=0, C(34)=0	14.70	0.0054	**Reject**

* Significant at 1% level of significance;

The above results points to the possibilities of following direction of causalities in a systems framework across different sectors:

While causality tests in VAR(1) point to bi-directional causality between industry and services, those in VAR(4) points to the presence of uni-directional causality from industry and services to agriculture over and above that. However, none of these systems points to any directional causality from agriculture either to industry or to services sector growth.

Unike Kalirajan and Shanker (2001) the recent Indian data does not seem to support the notion of bi-directional causality between industry and agriculture.

From policy perspective what matters is not only the direction of causality but their magnitude as well. Since this VAR is of I(0) variables, we can look at their impulse responses to get an overall hang of both their direction and magnitude as well.

An impulse response function traces the effect of a one-time shock to one of the innovations on current and future values of the endogenous variables – i.e. it simulates the effect of a shock to one variable in the system on the conditional forecast of another variable. For example if the response of industry after a shock in services growth is positive, then presumably industry will respond positively to innovations in services growth.

Table 4: Impulse responses to one unit innovation in VAR(1) and SE confidence band:

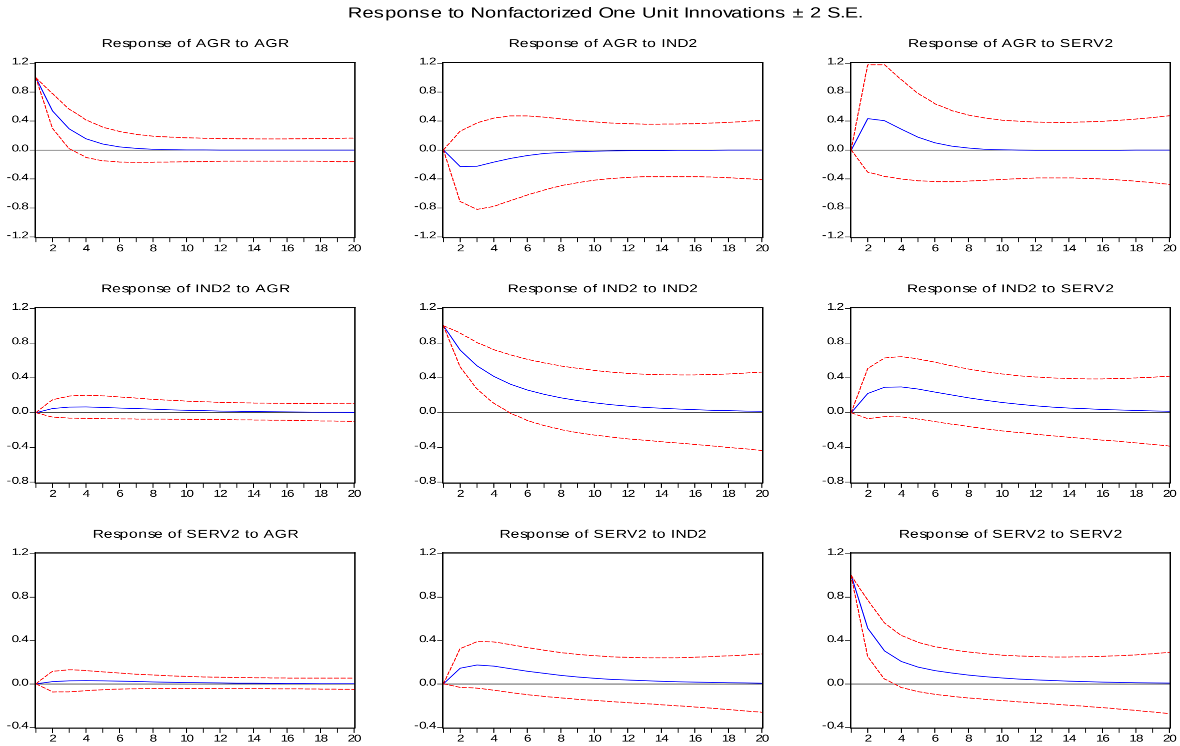
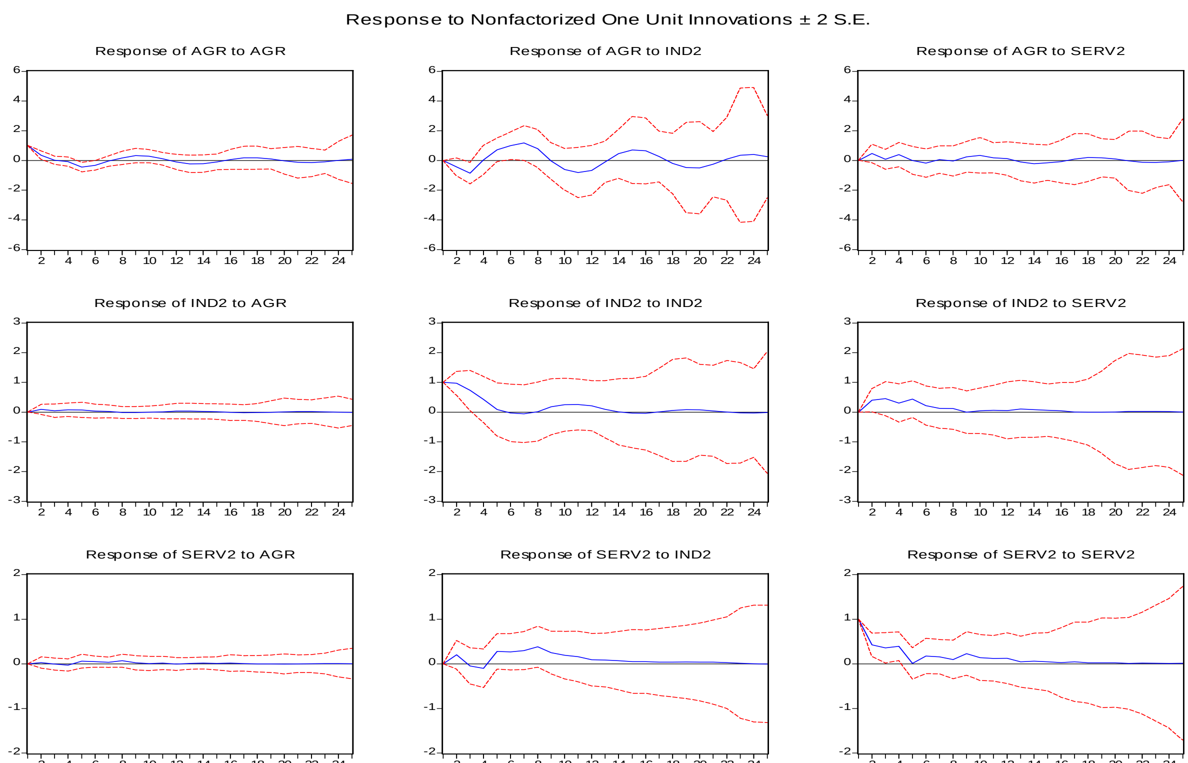


Table 5: Impulse responses to one unit innovation in VAR(4) and SE confidence band:



Impulse responses in both these system of equation convey the basic results of the causality tests: that growth in agriculture does not feed into either industrial or the services sector growth; and that there is positive bi-directional causality between industry and services. In case of VAR(1), services sector stands out to be the most important one in feeding positively into the growth of both agriculture and industry. However, in both these systems there appears to be some initial feedback from industry to agricultural growth which even if negligible remains negative in impact.

Without downplaying the importance of agriculture, the nature of such inter-sectoral relationships possibly indicates that at least any policy priority favoring services sector need not necessarily go against agricultural growth and if at all has significant positive linkages for it. This is more in tune with the results of Tarlok Singh (2009) even after allowing for explicit interactions between agriculture, industry and services rather then clubbing the first two sectors as non-services GDP.

3. Conclusion:

The aim of the study was to explore the inter-sectoral linkages that might exist in the more recent Indian GDP data. Granger causality analysis in a systems framework across VARs of different lag lengths supports the notion of bi-directional causality between industry and services, without pointing to any causality running from agriculture to either industry or services - ruling out agriculture in its current form as a driving force for non-agriculture growth. Though, the results do not rule out prospects of directional causality running from industry and services to agriculture.

Impulse responses in the two system of equation does convey the basic results that growth in agriculture does not feed into either industrial or the services sector growth and that there exists positive bi-directional causality between industry and services. In case of VAR(1), services sector stands out to be the most important one in feeding positively into the growth of both agriculture and industry. However, in both these systems there appears to be some initial negative even if negligible feedback from innovations in industrial growth to agricultural growth. The reason behind this is not exactly clear to us. It needs to be explored if at all this could be related to issues like increasing dependence of agriculture for its critical inputs on non-agriculture sector like chemical fertilizer or relative decline in the importance of agro based industries in the total output of registered manufacturing or there is something else that is not that obvious.

Exogenous shocks to economy through agriculture as a fall-out of adverse weather conditions remains a reality even today. In such an event, bi-directional sectoral linkages between industry and services (in the absence of directional causality running from agriculture to non-agriculture growth) can still help sustaining the growth momentum through appropriate policy initiatives favoring these sectors. Policy initiatives favoring industry and services in such a set up would be effective in neutralizing some of the negatives of adverse shocks from agriculture. In the same spirit adverse shocks either to industrial and/or services growths are likely to get magnified and policy initiatives directed towards agricultural growth to counter this need not be effective in yielding the desired result.

Without downplaying the importance of agriculture, the nature of such inter-sectoral relationships possibly indicates that at least any policy priority favoring services sector need not necessarily go against agricultural growth and if at all has significant positive linkages for it.

There can be no two doubts about the economic and social importance of agriculture for its contribution towards achievement of the national objectives of food security, employment, regional equilibrium and social cohesion. However, in its current structure the agriculture sector might have a limited role as a driving force for the other non-agriculture sectors of the India economy. That leaves behind some important question to be addressed as to why such an important segment of the economy housing the lion's share of population is failing to emerge as a driver of non-agricultural growth. Does it point to the lack of expanding economic opportunities and adequate investments in raising production and rural income when the same is happening in non-agriculture sectors? Does it point to the limited success of Indian agriculture policy in achieving self-sufficiency in food alone without being able to exploit the advantage of cheap raw materials and labour in developing agro-based industries? More so has the reforms process so far ignored the sectors capacity to contribute to a more rapid overall rate of economic growth?

To conclude, it must be said that the results presented here depends crucially on the definition of the variables used in this analysis. Extension of such analysis to levels of added granularity of sub-sectors and across states can make it lot insightful and richer.

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