Relationships among Per Capita GDP, Agriculture and Manufacturing Sectors in India

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Abstract The objective of the present paper is to examine causal relationship among per capita GDP, agriculture and manufacturing sector output in India using time series data collected from CSO for the period 1970 to 2013. The study conducts an econometric investigation by applying methodologies, viz., Stationary tests, and Johansen's Cointegration test, Johansen's Vector Error Correction Model (VECM) in VAR and Impulse Response Function and Variance Decomposition Analysis. We have carried out the ADF and KPSS unit root tests. According to AIC and HQC criteria, the appropriate lag length is 2. Both the variables in log terms being I (1), Johansen's co-integration test confirms one long run relationships among the variables at 5% significance level. It reveals that there exists bidirectional causality between agriculture sector and per GDP, while the unidirectional causality between the manufacturing sector and per capita GDP and between the agriculture and manufacturing sector. As the VECM involve selection of appropriate lag length. According to AIC criterion and Hannan-Quinn criterion; two lag lengths is considered to the present analysis. The signs of both the coefficients of the cointegrated equations are as expected and their magnitudes are responsible. However, results based on vector error correction model indicate a weak association between the sectors in the short run. Dynamic causality results show that the agriculture sector affects Per Capita GDP and manufacturing sector, while Per Capita GDP affects manufacturing sector strongly in the long run, thus causality seems to run from agriculture to PCGDP and manufacturing and from PCGDP to Manufacturing sector. It is also evident from impulse response function that any innovation in agriculture sector increases its own growth as well as growth of manufacturing sector in India. In consistence with the above finding, the present study argues that shocks originated from agriculture sector spill over to Per Capita GDP and Manufacturing sector in long run in India.

Keywords: *agriculture, manufacturing sector, Cointegration and Vector Error Correction Model, Impulse Response Function and Variance decomposition analysis*

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1. Introduction

Whether agriculture is more important for growth acceleration or manufacturing should be considered as the engine of growth has always been subject of research in all over the world. There is an empirically positive correlation between the degrees of industrialisation (mainly manufacturing) and per capita income in developing countries. The developing countries which now have higher per capita incomes have seen the higher share of manufacturing in GDP and have experienced high dynamic growth of manufacturing output and manufacturing exports. The poorest countries have failed to industrialise and still have very large share of agriculture in GDP. As per capita incomes rise, the share of agricultural expenditure in total expenditure declines and the share of expenditure on manufactured goods increase. In Indian perspectives it is also confirmed that

per capita GDP is positively correlated with share of manufacturing sector while there is significant negative correlation between per capita GDP and value added share of agriculture sector in GDP in India during 1970 – 2013 (Table 1). It is also disclosed from the Table 1 that the per capita GDP remained highest volatile followed by agriculture sector and manufacturing sector in India during the study period.

Table 1. Summary Statistics, using the observations 1970 - 2013

Variable	Mean	Std. Dev.	C.V.	Correlation
PCGDP	2050.75	1059.27	0.516529	1.0000
AS	23.2570	6.93010	0.297979	-0.9393
MS	14.8780	0.951079	0.0639254	0.6932

Compared to agriculture, the manufacturing sector offers special opportunities for capital accumulation. Productivity is higher in the manufacturing sector than in the agriculture sector. The transfer of resources from agriculture to manufacturing provides a structural change. Capital accumulation can be more easily realised in

spatially concentrated manufacturing sector than in spatially dispersed agriculture sector. This is one of the reasons why the emergence of manufacturing has been so important in growth and development.

India has maintained high and stable GDP growth rates during the three decades since 1981, during which the average real GDP growth rate was 5.8 percent. In spite of that the importance of agriculture in particular to its share in real GDP is diminishing. In East Asian countries, the manufacturing sector in urban areas has absorbed any surplus labour in rural areas via industrialisation. However, rural areas in India have agricultural labourers who cannot participate in the management of agriculture even through the rental market and who also do not own any land. These are the main reasons for the existence of poverty in India. On the other hand, opportunities for engaging in non-farm employment have expanded. It has been reported that the income of agricultural labourers has increased due to growth of non-farm employment in some rural areas. Therefore, it is necessary to examine what kinds of non-farm employment surplus labour are able to receive.

Since the late 18th century, the manufacturing sector has been the main engine of growth and catch up. Presently, however, service sector value added accounts for over 60 percent of GDP in India. In addition, ICT services have become important sources of growth particularly in India. This raises the question whether the manufacturing sector will continue to be the most important engine of growth, development and catch up for India in the 21st century.

In 1970, the share of manufacturing in GDP was 12.74%, compared to 34.16% share of agriculture in GDP of India. The share of manufacturing increased 14.9% and agriculture declined to 27.9% in 1979-80. Again the share of manufacturing increased 15.2% and agriculture declined to 25.2% in 1989-90. The decline in the share of agriculture is remained continue in further decades 19.6% and 12.4% in 1999-2K and 2009-10 and presently in 2013-14 it remained 11.9% but the increase in the share manufacturing sector was observed till 1996-97, when it reached 16.6%. It then declines to 15% in 1999-2K and further reaches to 16.2% in 2009-10 and presently in 2013-14 it remained 14.9% (Figure 1).
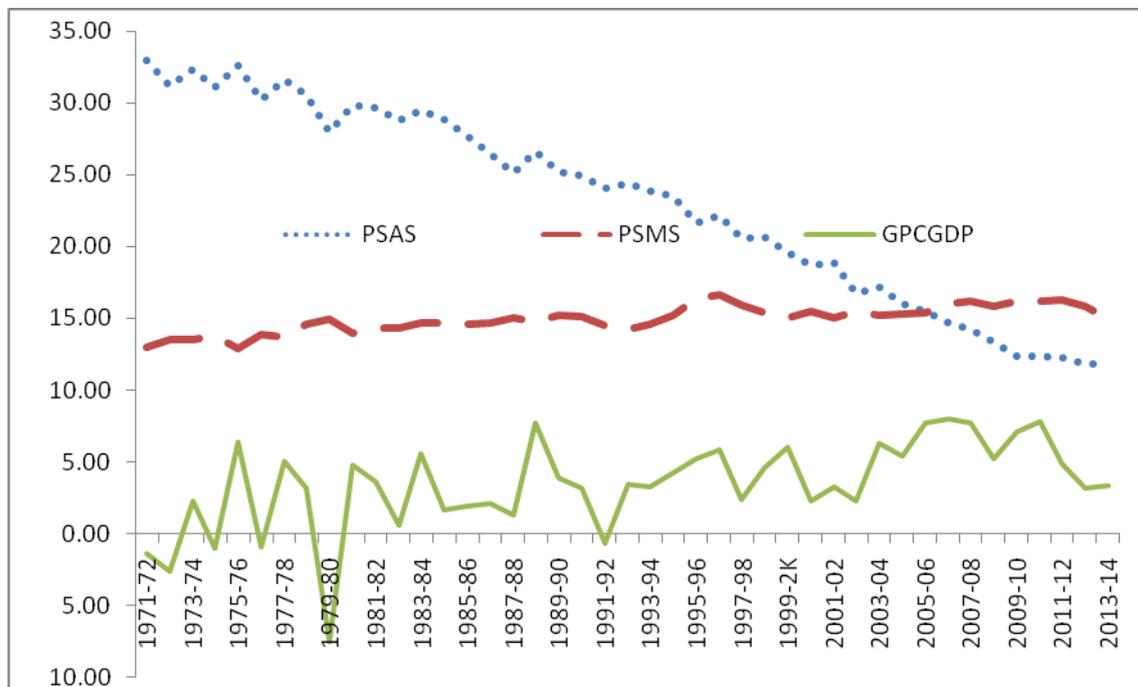

Figure 1. Relationship among growth of per capita GDP and value added share of agriculture and manufacturing sectors in India during 1971-2014

The present paper is structured as follows. In section 2, we briefly review some of the recent contributions in the literature. Section third develops hypotheses which guide our empirical analyses. Data and methods are discussed in section 4. The preliminary empirical results are presented in section 5 and Section 6 deals with some conclusions and suggestions based on present analysis.

2. Review of Literature

Contributions of manufacturing sector can be measured in different ways: using growth accounting techniques and econometric analysis (Bosworth, Collins and Chen, 1995; Fagerberg and Verspagen, 1999, 2002, 2007; Timmer and de Vries, 2009). Econometric analysis is more popular and simply using regression equations. These techniques are straightforward and transparent.

Fagerberg and Verspagen (1999) uses simple regression model of real growth rates of GDP on growth rates of manufacturing. If the coefficient of manufacturing growth is higher than the share of manufacturing in GDP, this is interpreted as supporting the engine of growth hypothesis. Fagerberg and Verspagen found that manufacturing was typically an engine of growth in developing countries in East Asia and Latin America, but that there was no significant effect of manufacturing in the advanced economies.

In a second article Fagerberg and Verspagen (2002) examined the impact of shares of manufacturing and services on economic growth in three periods: 1966-72, 1973-83 and 1984-95 for a sample of 76 countries. They found that manufacturing has much more positive contributions before 1973 than after. The interpretation in both papers is that the period 1950-1973 offered special opportunities for catch up through the absorption of mass

production techniques in manufacturing from the USA. After 1973, ICT technologies started to become more important as a source of productivity growth, especially in the nineties. These technologies are no longer within the exclusive domain of manufacturing, but operate in the service sector.

Szirmai (2009) examined the arguments for the engine of growth for a limited sample of Asian and Latin American developing countries. He focused on capital intensity and growth of output and labour productivity. His results are again somewhat mixed. In general he finds support for the engine of growth hypothesis, but for some periods capital intensity in services and industry is high than in manufacturing. In advanced economies productivity growth in agriculture is more rapid than in manufacturing.

Rodrik (2009) used regression model for growth rates of GDP for five year periods on shares of industry in GDP in the initial year, following the same approach as in this paper, but not distinguishing manufacturing from industry. He finds a significant positive relationship and interprets the growth of developing countries in the post war period in terms of the structural bonus argument. He explicitly concludes that transition into modern industrial activities acts as an engine of growth. For Rodrik structural transformation is the sole explanation of accelerated growth in the developing world.

Tregenna (2007) analyses the important of manufacturing for South African economic development and concludes that manufacturing has been especially important through its strong backward linkages to the service sector and other sectors of the economy. For India two recent papers reach contradictory conclusions. Katuria and Raj (2009) examine the engine of growth hypothesis at regional level for the recent period and conclude that more industrialised regions grow more rapidly. On the other hand Thomas 2009 concludes that services have been the prime mover of growth resurgence in India since the 1990s. A similar position is taken by Dasgupta and Singh (2005). In an econometric analysis for India Chakravarty and Mitra (2009) find that manufacturing is clearly one of the determinants of overall growth, construction and services also turn out to be important, especially for manufacturing growth.

A recent article by Timmer and de Vries (2009) also points to the increasing importance of the service sector in a sample of countries in Asia and Latin America. Using growth accounting techniques, they examine the contributions of different sectors in periods of growth accelerations, in periods of normal growth and in periods of deceleration. In periods of normal growth they find that manufacturing contributes most. In periods of acceleration, this leading role is taken over by the service sector, though manufacturing continues to have an important positive contribution.

Debnath and Roy (2012) analyzed the trend in sectoral shares in state domestic product and inter-sectoral linkages in northeast India for the period 1981 to 2007 in his paper. They show that there exists bidirectional causality among the sectoral output of northeastern states, at least in the short run. In the long run, there exists a unidirectional causality running from the agricultural sector and the industrial sector to the services sector.

From the above discussion, it has seen that the importance of sectoral linkages is useful to understand the association between different sectors in the economy. In sum, both the empirical information contained in this paper and the secondary literature presents a somewhat mixed picture. Manufacturing is seen as important in several papers, especially in the period 1950-73 and in recent years more so in developing countries than in advanced economies. In the advanced economies, the contribution of the service sector has become more and more important and the share of services in GDP is now well above 70 per cent in the advanced economies.

3. Research Questions/Hypotheses

To guide our empirical analysis we have formulated a set of working hypotheses which take a strong version of the engine of growth hypothesis as point of departure.

1. Is there a positive relationship between the value added share of manufacturing and growth of GDP per capita in India? Our hypothesis is that there is a positive relationship in the period 1970-2013 for India.

We examine this hypothesis by regressing per capita GDP growth rates on manufacturing shares for 43 years period. A significant positive relationship indicates that expansion of the share of manufacturing contributes to economic growth.

Model 1. OLS, using observations 1971-2013 (T = 43), Dependent variable: GPCGDP

	Coefficient	Std. Error	t-ratio	p-value	
const	-20.3447	7.3248	-2.7775	0.00822	***
PSMS	1.59625	0.489812	3.2589	0.00225	***

R-squared	0.205741	Adjusted R-squared	0.186368
F(1, 41) P-value	10.62*	Durbin-Watson	2.392563

2. Is the relationship between the values added share of manufacturing and per capita GDP growth stronger than that between the value added share of agriculture and growth of per capita GDP? Our hypothesis is that the relationship between manufacturing and per capita GDP growth is strong than between agriculture and per capita GDP growth.

We add the share of agriculture to the regression. If the coefficient of manufacturing shares is substantially higher than the coefficient of agriculture sector shares, this is interpreted as support for the engine of growth argument. Also, if the coefficient of manufacturing share is significant and the coefficient of agriculture is not, this is interpreted as support for the engine of growth argument. According to regression equations, it can be concluded that when we conduct two separate equations than there is significant negative association with agriculture and significant positive association with manufacturing sector during 1971-2013 in India, but when we use both variables (PSAS & PSMS) as independent variables than there is not any significant links, though the coefficient of manufacturing share is positive and the coefficient of agriculture share is negative. Hence it could be concluded that manufacturing sector is acted as support for the engine of growth.

Model 2. OLS, using observations 1971-2013 (T = 43), Dependent variable: GPCGDP

	Coefficient	Std. Error	t-ratio	p-value	
const	8.77868	1.52065	5.7730	<0.00001	***
PSAS	-0.230186	0.0634507	-3.6278	0.00078	***

R-squared	0.242997	Adjusted R-squared	0.224533
F(1, 41) P-value	13.16*	Durbin-Watson	2.319131

Model 3. OLS, using observations 1971-2013 (T = 43), Dependent variable: GPCGDP

	Coefficient	Std. Error	t-ratio	p-value
const	-0.625644	14.6055	-0.0428	0.96605
PSAS	-0.171707	0.110642	-1.5519	0.12856
PSMS	0.539877	0.833837	0.6475	0.52103

R-squared	0.250848	Adjusted R-squared	0.213390
F(2, 40) P-value(F)	6.69*	Durbin-Watson	2.414710

3. Does the relationship between the share of manufacturing and growth of GDP per capita become stronger over time?

Our working hypothesis is that the relationship between manufacturing and growth will be stronger in the period 1992-2013 than in the period 1971-1991. This is assessed by two separate regression equations estimating for each of the time periods. If the coefficient of the post liberalisation period is substantially higher than the coefficient of pre liberalisation period, this is interpreted as support for the engine of growth argument. If we find that the relationship between the share of manufacturing and growth is becoming stronger over time, this indicates that manufacturing sector is acting as an engine of growth in the post-liberalisation period.

Model 4. OLS, using observations 1971-1991 (T = 21), Dependent variable: GPCGDP

	Coefficient	Std. Error	t-ratio	p-value
const	-0.13501	17.3985	-0.0078	0.99389
PSMS	0.142115	1.21789	0.1167	0.90833

R-squared	0.000716	Adjusted R-squared	-0.051878
F(1, 19) P-value	0.013	Durbin-Watson	2.412929

Model 5. OLS, using observations 1992-2013 (T = 22), Dependent variable: GPCGDP

	Coefficient	Std. Error	t-ratio	p-value	
const	-15.691	9.82415	-1.5972	0.12590	
PSMS	1.33037	0.631141	2.1079	0.04786	**

R-squared	0.181776	Adjusted R-squared	0.140864
F(1, 20) P-value	4.44**	Durbin-Watson	1.391016

4. Methodology and Data Sources

The objective of this paper is to examine the causal relationship among per capita GDP, agriculture sector output and manufacturing sector output in India using time series data from 1970 to 2013. For the purpose, Co integration test has been conducted to determine whether groups of non-stationary series are Co integrated or not, we applied following methodologies:

1. Stationary Test;
2. Johansen's Co integration Test;
3. Johansen's Vector Error Correction Model (VECM) in VAR; and
4. Dynamic Analysis in a Co integrated VAR Framework: Impulse Response Function and Variance Decomposition Analysis.

To examine the stationary property of all the variables used in this paper, we have carried out the ADF and KPSS unit root tests. All the tests have been conducted with and without trend. If the data generating process is following a unit root and therefore non-stationary, then the data has to be transformed into first differences and unit root test has to be repeated. If the data in first differences follow a stationary process, or if data in different forms is stationary, then the variables in levels form have to be tested for any Co integrating relationships (Engel and Granger 1987) and Johansen and Juselius (1990). If in the level form, there is Co integration, the vector Error Correction Model is to be run, and the Granger Casualty can be tested for both long run and short run, Further, in order to Analyse the dynamic interaction among the variables, the paper has made the use of Variance Decomposition analysis and the impulse response function. These are generally used to overcome the shortcoming of VAR approach; the coefficients obtained from the VAR Model cannot be interpreted directly (Litterman, 1979). The VAR Approach consists of a set of regression equations in which all the variables are considered endogenous. Data used in this paper are collected from the Data Book for PC by Central Statistical Office of India (CSO 2014). All data are annual figures of an Indian economy; covering the 1970-71 to 2012-13 period and variables that are measured is at a constant 2004-05 prices.

5. Estimation Equation and Result Interpretation

At the outset, before undertaking any time series econometric analysis of the data, it would be useful to see the broad trends and behaviour of the variables, which may help in interpreting the model results later. For this purpose, time series plot is drawn for all the variables. In the next step, we have computed the descriptive statistics of all the selected variables. The summary statistics are presented in the Table 1.

To examine the stationary property of the variables, we have carried out the ADF and KPSS tests (Table 2) and drawn time series plots for log PCGDP, log PSAS and log PSMS in level and difference form (Figure 2). The null hypothesis is that there exists a unit root or the underlying process is non stationary. The results indicate that per capita gross domestic product (PCGDP), Agriculture Sector (AS) and Manufacturing Sector (MS) value added are integrated of order one I (1). The same conclusion is derived from the KPSS test.

The next step is to examine the interaction among the variables in the system using the vector error-correction model. The VECM involves selection of appropriate lag length. An appropriate lag selection may give rise to problems of over-parameterizations or under parameterization.

The resulting lag structures are reported in Table 3. According to AIC and HQC criteria, the appropriate lag length is 2. Mathematically, two or more variables are said to be co-integrated if they are individually integrated of the same order, say (p), and a linear combination of the variables exists such that their linear combination is stationary, i.e. I (0). Generally, existence of co-integration is examined by two alternative approaches, viz., The Engle-Granger two step method proposed by Engel and Granger (1987) and Johansen-Juselius method proposed by Johansen (1988) and later extended by Johansen and Juselius (1990). The Engle – Granger method is basically a test for unique co-integrating relationship, while the Johansen-Juselius method can be applied to test for the existence of more than one co – integrating relationship. The number of co-integrating vectors based on the Johansen - Juselius method is determined by two test statistics, viz., The Trace Statistics and the Maximal Eigenvalues Statistic. The trace Statistic examines the null hypothesis that the number of distinct co-integrating vectors is less than or equal to 'r' against a general alternative. The Maximal Eigenvalue Statistic tests the null hypothesis that the number of co-integrating vectors is 'r' against the alternative of 'r+1' co-integrating vectors.

Table 2. Unit Root Tests of the Variables

Tests	ADF Test Level		ADF Test First Difference		KPSS Test Level	
Variables	C	C+T	C	C+T	C	C+T
lnPCGDP	3.58	-1.62	-5.51*	-7.44*	1.15*	0.29
lnAS	0.71	-1.79	-10.69*	-11.57*	1.14*	0.29
lnMS	-2.66	-3.24	-6.66*	-6.78*	1.01*	0.14

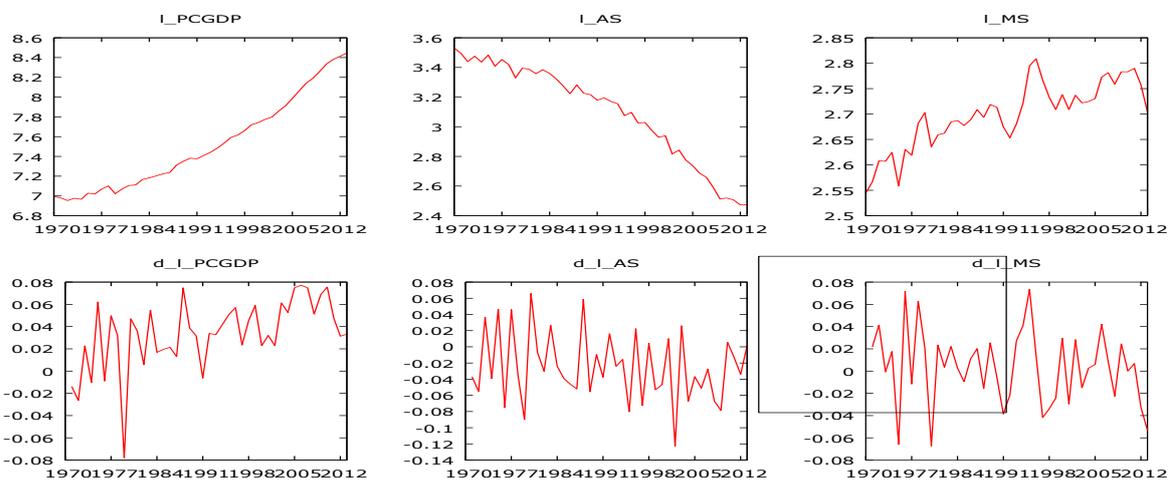C- Constant, C+T – Constant and trend. * Significant at 5% or lower level.

Figure 2. Level and First difference time series plotting of log PCGDP log AS and log MS

Table 3. VAR Lag Order Selection Criteria

The asterisks below indicate the best (that is, minimized) values of the respective information criteria, AIC = Akaike criterion, BIC = Schwarz Bayesian criterion and HQC = Hannan-Quinn criterion.

lags	loglik	p(LR)	AIC	BIC	HQC
1	273.80120		-13.090060	-12.583396*	-12.906866
2	285.85145	0.00415	**-13.242573***	-12.355911	**-12.921984***
3	291.96889	0.20039	-13.098444	-11.831785	-12.640460
4	302.74963	0.01038	-13.187482	-11.540824	-12.592102

Table 4. Empirical Results of the Co-integration Tests based on Johansen-Juselius method

Variables in the system	Rank	Eigenvalue	Trace Test [p-value}	Lmax test [p-value]	Conclusion
1	2	3	4	5	6
LPCGDP, LAS	0	0.38520	24.555 [0.0013]	20.31 [0.0037]	Two co-integrating relationship exist
	1	0.09351	4.1235 [0.0423]	4.12 [0.0423]	
LPCGDP, MS	0	0.54082	34.313 [0.0000]	32.689 [0.0000]	One co-integrating relationship exist
	1	0.03792	1.6239 [0.2026]	1.6239 [0.2026]	
LAS, MS	0	0.28002	16.116 [0.0386]	13.798 [0.0574]	One co-integrating relationship exist
	1	0.05370	2.318 [0.1279]	2.3183 [0.1279]	
LPCGDP, LAS, LMS	0	0.59015	55.744[0.0000]	37.462 [0.0000]	Two co-integrating relationship exist
	1	0.33673	18.282 [0.0170]	17.244 [0.0145]	
	2	0.02441	1.0382[0.3082]	1.0382[0.3083]	

Since there are more than two variables, there may be more than one Co integrating relationships. Thus, it is appropriate to examine the issue of Co integration within the Johansen VAR framework. All the variables are tested under Johansen's technique and results have been presented in Table 4. The trace test indicates that the null

hypothesis of at most 1 Co integrating vector is rejected and the Max-Eigenvalue test also confirms this result. It is evident from the table 4 that both Trace and Eigenvalue criteria rejects the null hypothesis of at most none Cointegrating vector against the alternative of at most one Cointegrating vector for all four specifications.

1. Per Capita GDP and Agriculture Sector

At the outset, we attempted to explore the relationship between per capita GDP and agriculture sector. Both the Trace Statistics and Maximal Eigenvalue Statistic reject the null hypothesis of no Cointegration (Table 4). It suggests that there is bidirectional causality existed between agriculture and per capita GDP. The estimate of long run equation with short run dynamic ECM equation for the period 1970-71 to 2012-13 is presented below. The estimated of coefficient of the error term indicates speed of adjustment of per capita GDP towards the equilibrium state. The state corrects approximately 36 percent of their error during one year.

Long - run Equation

$$Log\ (PCGDPt) = 12.223 - 1.497\log(AS)$$
$$(0.15) \quad (0.44)$$

beta (Cointegrating vectors, standard errors in parentheses)
ECM Equation:

$$D\log(PCGDPt) = -\mathbf{0.361}ECM_{t-1}$$
$$(SE) \qquad\qquad (0.068)$$
$$+0.285D\log(PCGDP_{t-1}) + 0.047\ D\log(AS_{t-1})$$
$$(0.092) \qquad\qquad (0.118)$$

Adjusted R-squared = 0.768 Durbin-Watson = 1.96.

2. Manufacturing Sector and Per Capita GDP

We further attempted to explore for existence of relationship between the manufacturing sector and per capita GDP. Both the Trace Statistic and Maximal Eigenvalue Statistic suggest existence of one Cointegrating relationship. The ECM equation indicates that approximately 29 percent of previous year error is corrected in the current year. The estimates of both long run as well as short run ECM equations presented below:

Long - run Equation

$$Log\ (MSt) = 2.76 - 0.022\log(PCGDP)$$
$$(0.18)\ (0.025)$$

beta (Cointegrating vectors, standard errors in parentheses)
ECM Equation:

$$D\log(MSt) = -\mathbf{0.288}ECM_{t-1}$$
$$(SE) \qquad\qquad (0.05)$$
$$+\mathbf{0.849}D\log(PCGDP_{t-1}) + 0.161D\log(MS_{t-1})$$
$$(0.139) \qquad\qquad (0.124)$$

Adjusted R-squared = 0.463 Durbin-Watson = 1.88.

3. Agriculture and Manufacturing Sector

In line with above, we further attempted to explore for existence of relationship between the agriculture sector and the manufacturing sector. The Trace Statistic indicates the existence of one long - run equilibrium relationship at 5% level, while the Maximal Eigenvalue Statistic indicates the existence of one long - run equilibrium

relationship at 10% level. The long run and short run equations display an insignificant yet positive relationship between agriculture and manufacturing sector during 1971-2013 in India. The ECM equation indicates that approximately 21% of previous year error is corrected in the current year. It suggests that one year lag agriculture sectors share is negatively associated with present year's share of agriculture sector in India.

Long - run Equation

$$Log\ (MSt) = 2.31 + 0.066\log(AS)$$
$$(0.28)\ (0.89)$$

beta (Cointegrating vectors, standard errors in parentheses)
ECM Equation:

$$Dlog(ASt) = -\mathbf{0.205}ECM_{t-1}$$
$$(SE) \qquad\qquad (0.037)$$
$$-\mathbf{0.558}D\log(AS_{t-1}) + 0.0485\ D\log(MS_{t-1})$$
$$(0.167) \qquad\qquad (0.213)$$

Adjusted R-squared = 0.41 Durbin-Watson = 2.138.

4. Per Capita GDP, Agriculture and Manufacturing Sector

After establishing the existence of bivariate long – run relationship between per capita GDP and different sectors, we attempted to explore for existence of Cointegration relationship among per capita GDP, agriculture and manufacturing sectors. Mathematically, both the Trace Statistic and Maximal Eigenvalue Static indicate existence of at most two Cointegrating relations among the three variables. The estimate of the long - run relationship is found in below given equation. Sign of the estimated coefficient in respect of the agriculture sector is found to be negative, which suggests that the share of agriculture sector and per capita GDP move in opposite direction while the positive coefficient for the share of manufacturing sector suggests that the share of manufacturing sector and per capita GDP move in same direction in India. The ECM equation indicates that approximately 12 percent of previous year error is corrected in the current year.

Long - run Equation

$$Log(PCGDPt) = 6.61 + 2.11\log(MS) - 1.475\log(AS)$$
$$(SE) \qquad (1.42)\ (0.44) \qquad (0.09)$$

beta (Cointegrating vectors, standard errors in parentheses)
ECM Equation:

$$Dlog(PCGDPt) = -\mathbf{0.118}ECM_{t-1} + 0.086Dlog(PCGDPt-1)$$
$$(SE) \qquad\qquad (0.03) \qquad\qquad (0.15)$$
$$-0.11Dlog(AS_{t-1}) + 0.16Dlog(MS_{t-1})$$
$$(0.15) \qquad\qquad (0.14)$$

Adjusted R-squared = 0.71 Durbin-Watson = 1.99.

$$D\log(AS_t) = -0.03\ ECM_{t-1} - 0.91\ D\log(PCGDPt-1)$$
$$(SE) \qquad (0.04) \qquad\qquad (0.22)$$
$$+0.116\ D\log(MS_{t-1}) - 0.05\ D\log(AS_{t-1})$$
$$(0.19) \qquad\qquad (0.21)$$

Adjusted R-squared = 0.49 Durbin-Watson = 2.26.

$$\text{Dlog}(\text{MS}_t) = \mathbf{0.155}\text{ECM}_{t-1} + \mathbf{0.88}\text{Dlog}(\text{PCGDPt}-1)$$

$$\text{(SE)} \qquad (0.03) \qquad (0.15)$$

$$+0.486\,\text{D}\log(\text{MS}_{t-1}) - \mathbf{0.3}\text{Dlog}(\text{AS}_{t-1})$$

$$(0.13) \qquad\qquad (0.15)$$

Adjusted R-squared = 0.46 Durbin-Watson = 1.77.

5.1. Dynamic Analysis in a Cointegrated VAR Framework: Impulse Response and Variance Decomposition Analysis

After investigating the long-run relationship and short-run adjustment dynamics of per capita GDP, agriculture and manufacturing sectors in India, the study has made use of the VAR model and reported the impulse response functions and variance decomposition results in order to analyse the dynamic interaction among the variables.

5.1.1. Variance Decomposition Analysis

The magnitude of variance explained at the 10th time horizon by different components is presented in Table 5. It is observed that 52.85 percent variance in Per Capita GDP explained at the 10th time horizon is explained by agriculture sector, whereas Per Capita GDP explains 4.4 percent variance in agriculture at the same time horizon. Hence, the agriculture sector affects Per Capita GDP strongly in the long run, and, thus causality seems to run from agriculture to PCGDP. Similarly, between the PCGDP and Manufacturing sector, it is observed that 63.5 percent Variance in manufacturing sector is explained by Per Capita GDP, whereas Variance in Per Capita GDP explained by manufacturing sector is only 7.3 percent at the same time horizon. Hence, Per Capita GDP affects Manufacturing sector strongly in the long run and, thus

causality seems to run from PCGDP to Manufacturing sector. In consistence with the above finding, the present study argues that shocks originated from Per Capita GDP spill over to Manufacturing sector in long run in India. Between the Agriculture and Manufacturing sectors, 11.3 percent Variance in manufacturing sector is explained by the Agriculture sector while the Manufacturing sector explains only 1.4 percent variance in the Agriculture sector. Thus, causality runs from the agriculture sector to the manufacturing sector.

Table 5. Magnitude of Variance explained at the 10ᵗʰ Time Horizon by Different Components

Variance in Agriculture sector explained by Per Capita GDP	4.36	Variance in Per Capita GDP explained by Agriculture sector	**52.85**
Variance in Per Capita GDP explained by Manufacturing sector	7.31	Variance in Manufacturing sector explained by Per Capita GDP	**63.49**
Variance in Agriculture sector explained by the Manufacturing sector	1.38	Variance in Manufacturing sector explained by the Agriculture sector	**11.3**

5.2. Impulse Responses

The impulse response function analyzes the responsiveness of dependent variables to shocks of each of variables in a cointegrated VAR framework. As depicted in the Figure 3 that innovations in manufacturing sector have a positive impact in per capita GDP, while for the agriculture sector, it shows a heavy decline in the second year and then moves onwards. Agriculture sector initially reduces its own growth as well as the growth of Per Capita GDP. On the other hand, it increases the growth rate of the manufacturing sector in the medium and long run. From Figure 3, it is evident than any innovation in agriculture sector increases its own growth as well as growth of manufacturing sector in India.
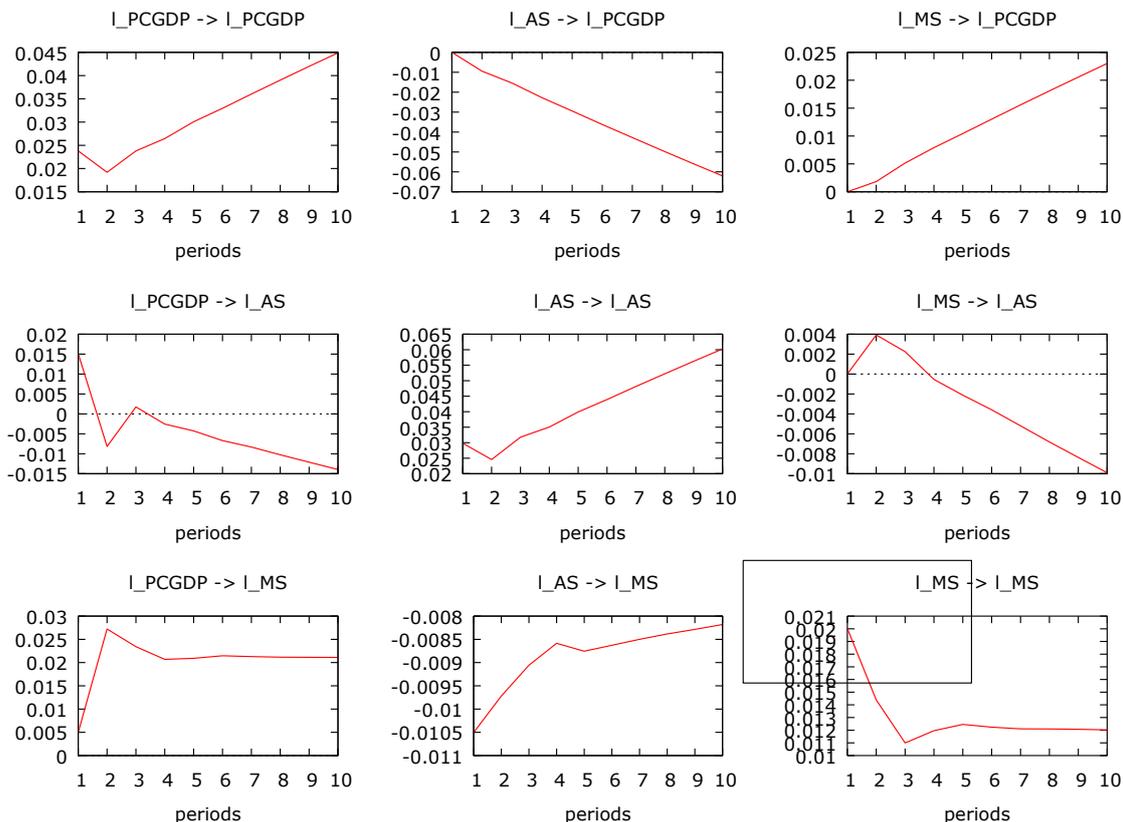

Figure 3. Combined Impulse Responses of log PCGDP, log AS and log MS (Note: Y axis measures the impacts and X axis denotes the time trend)

6. Concluding Remarks

Some of the recent secondary empirical literature (e.g. Fagerberg and Verspagen, 1999, 2002; Timmer and de Vries, 2009), confirms the important role of manufacturing sector for growth and catch up in developing countries, but does it indicate that this role is weakening over time. The strongest contributions are found in the period 1950-1973, when there were special opportunities for absorption of mass production techniques by developing countries. In the advanced economies, the role of services has become much more important.

We have analysed the causality and co-integration relationship between sectoral GDPs of agriculture, manufacturing and the per capita GDP of India during the period 1970-71 – 2012-13. Since the ADF test results indicate a first order integration, 1 (I) of the variables under consideration, we have employed the Johansen and Juselius (1990) Cointegration test, VECM, Impulse response and Variance decomposition analysis to examine the static and dynamic relationships between the variables. Johansen and Juselius (1990) Cointegration test reveals that there exists bidirectional causality among the agriculture and per capita GDP, while there is a unidirectional causality between agriculture and manufacturing sector.

To devise an appropriate strategy for accelerating the growth rate, the present paper examines inter-sectoral linkages to identify the lead sector in the economy using a VAR framework. The results suggest that the agriculture sector plays the main role in determining the overall growth rate of the economy through its linkages to other sector. The analysis of inter – sectoral linkages identify agriculture as the main economic activity that controls most economic activities in manufacturing sector as well as in per capita GDP (which is a proxy measure of economic growth) in India. Thus, the results suggest that the agriculture sector plays the main role in determining the overall growth rate of the economy through its linkages to the other sectors. The present analysis identifies agriculture as the main economic activity that controls even manufacturing activity in India.

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