Studying the Impact of Investment on Agricultural Output: An Application of Vector Error Correction Model (VECM)

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Abstract

The main aim of this paper is to examine the impact of public and private investment on gross value added (GVA) by the agriculture and allied sector. The study uses an annual time series data from 1970-71 to 2015-16 for several factors to develop a vector error correction model. Variables like Gross Irrigated Area (GIA), Fertilizer Consumption and Institutional Credit, Gross Fixed Capital Formation (GFCF) by the Public (GFCF_Pub) and Private (GFCF_Pri) sector have been used in the model. Four such models are developed and their results interpreted to arrive at the model that generates results closest to a priori expectation. The cointegration results suggest that there exists a long run equilibrium between the determinants and the GVA of the agricultural sector. GIA and GFCF_Pri have been found to have a significant and positive impact on the agricultural output. The study suggests that the government should take measures to revive public investment, attract private investment, ensure easy access to rural credit and incentivise farmers to undertake cultivation of crops other than commercial crops so as to diversify income stream and enhance agricultural output which will be beneficial for overall development of the sector.

Keywords: Investment; Agricultural output; Agriculture Orientation Index; VECM

Introduction

Agriculture and allied activities are often considered as the key drivers of the economy, primarily due to the fact that the growth of other sectors is dependent on the performance of the agricultural sector. In a developing economy like India, where as per the 2011 census about 68% of the population lives in rural areas, the agriculture sector acts as a source of employment and a major contributor to the growth of these regions. While, the relative share of agriculture and allied activities in the GVA (gross value added) of the total economy has reduced from 18.2% in 2014-15 to 16.5% in 2019-20 (Economic Survey,2019-20); the percentage share of agricultural workers (that is, cultivators and agricultural labours) in total workers as per 2011census is still at about 54.6% (Agricultural Statistics at a Glance,2019). It is due to this reason that over the years the agriculture and allied activities is still of vital interest to policy makers and receives a major share of the annual budgetary expenditure of the central and state governments.

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The farming system in India is highly heterogenic, for instance, Punjab that accounts for 1.6% of the agricultural households in India has an average monthly income of Rs18059 earned by agricultural households while the average monthly income of agricultural households in West Bengal that accounts for 7.1% of the total agricultural households in India was Rs3980 only (NSS report,2012-13). Similarly, the report highlights, only 15% of the households with landholding size <0.01 ha were able to access institutional sources of credit compared to 79% of those households with landholdings of >10 ha. With about 69% of the landholdings being of less than 1 hectares (Agricultural Statistics,2019), when coupled with skewed access of basic infrastructure like credit facility, electricity, irrigation etc. leads to an inefficient allocation of resources, that is, a market failure which creates a vacuum for investment in rural areas. This has been a well-documented fact that private sector investment in rural public goods has been limited due to the public nature of these goods (i.e., non-rival and non-excludable) and the consequent inability to charge for the costs (Fan et al.,2004). In the absence of an efficient market, on-farm investment has also largely been reduced to self-financing by the owners of landholdings (Singh et al.,2015). Hence, based on the Keynesian view, public investment in the rural public goods can raise productivity, reduce poverty and further increase investment (public as well as private) due to the multiplier effect.

There has been a general consensus on the effectiveness of public expenditure in correcting market failure, improving equity as well as of incentivising private investment by establishing infrastructure (FAO,2012). It is not necessary that the income distribution in a market economy is always equitable. For instance, small landholders are at the forefront of economic losses due to natural disasters or crop failure, which further affects their limited earnings. Government expenditure can be effective for this purpose. Literature also indicates the presence of a strong relation between the expenditure on public goods and rural growth driven through agriculture and hence concludes investment in R&D and infrastructure as the most optimal way to increase profitability (Fan et al.,2004).

As aforementioned, due to its role in the growth of agriculture and rural regions, FAO cites increased investment as one of its targets under goal 2 of promoting sustainable agriculture out of the total 17 goals highlighted by the UN as SDG's that are to be achieved by 2030. Due to the noted benefits of public expenditure in promoting investment, the FAO measures the performance of the nation in its ability to invest in agriculture and allied sectors relative to its contribution in the economy through the 'Agriculture Orientation Index (AOI)'. As the index takes into account a country's economic size, agriculture contribution to GDP and the total amount of government expenditure, it acts as a useful tool to establish universal targets as well as conduct cross-sectional analysis (UN SDGs,2020).

As recent studies indicate a falling share of agriculture in government expenditure in India even after the prevalence of widespread poverty and poor infrastructure in rural parts (Singh,2014), the question arises what factors play a significant role in improving productivity of the agricultural and allied sectors and whether the falling role of public expenditure is justified. Hence, through this paper an attempt has been made to study the impact of public investment and private investment in the agriculture and allied sectors on the agricultural output.

Literature Review

Multifunctionality of Agriculture –

The concept of multifunctionality has been a key issue in policy decisions of the agriculture sector. As an economic activity, the agriculture sector jointly produces several commodity and non-commodity outputs which helps to achieve several economic and societal objectives (OECD 2001). However, several of the non-commodity outputs exhibit properties of public goods (Jongeneel et al,2010), which implies that the current market structure is not efficient enough to provide pareto optimality. This inter-connectedness between outputs makes it difficult to respond to a public good in isolation of others (Kipling,2019). This is known as multifunctionality in agriculture.

For instance, the agriculture sector primarily produces output in terms of stock of grains, fruits, poultry etc. However, the sector at the same time jointly produces several externalities which have an impact on each other. These non-commodity outputs may include sustainability, food security, biodiversity, soil conservation, social and economic development of rural areas and many more.

Hence, although the agriculture sector produces private goods but the associated public goods or externalities which are jointly produced provide scope for intervention. Dr Kipling (2019) suggests that one of the means to achieve social welfare is by supporting production of a private good (say food production) as it has a positive impact on commodities that are considered to be public goods – e.g.- economically viable farming is considered to have an important role in economic and social development of rural communities.

Provision of Public Goods –

Adam Smith in his work ‘An Inquiry into the Nature and Causes of the Wealth of Nations’ underlines the primary expenses of a government, all of which can be arguably considered as provision of public goods. The first and second role of a government according to Smith are to fund military that defends the nation from any external invasion and to develop a justice system that protects every member of the society from oppression and injustice respectively. The third and last duty of the government Smith writes,

‘is that of erecting and maintaining public institutions and public works which, though they may be in the highest degree advantageous to a great society, ...no individual or small number of individuals could be expected to erect or maintain.’

The other public works besides defence and judiciary are chiefly for (a) facilitating the commerce of the society, (b) promoting education of the youth, and (c)promoting the instruction of people of all ages.

However, the major restriction that a government faces to execute its responsibilities is of the limit of funds. Therefore, most of the public investment are generally channelled towards provision of essential public goods with high economic and social returns, which varies by location and over time (FAO, 2012). While public investment in agro-favourable areas with easy access to markets are preferred as it improves agricultural productivity and further reduce poverty because of the spill-over benefits enjoyed by the residents of remote regions who migrate to these favourable regions for better opportunities (Palmer-Jones and Sen, 2003). However, as the marginal costs of achieving further gains in well-endowed regions increase over time after the easy gains have been achieved; government often undertakes investment in less favourably endowed agro-ecological regions that largely yield higher returns in terms of poverty reduction.

In a similar manner, the degree of public investment also varies based on the area of investment. As the FAO report (2012) on 'Investment in Agriculture' states that investment in agricultural research, rural roads, sustainable natural resource management and education have higher payoffs for society in terms of both agricultural growth and poverty reduction. Therefore, the report suggests that the corpus of public expenditure must primarily comprise of capital expenditure with long-term impacts. But a common practice that has been witnessed across the world in administrations of developing as well as developed countries is that a significant amount of government expenditure is earmarked for current expenditure in the form of subsidies (FAO,2012). The common argument given in favour of subsidies is that they help to mitigate negative externalities and expand farming to marginal areas. However, evidence suggests that despite the returns from subsidies tend to be short-lived (Fan, Gulati and Thorat, 2008), they are over-used by the government. In India itself, the agricultural subsidies have risen from 40% of agricultural public expenditures in 1975 to 75% in 2002 (World Bank, 2007a). These agricultural subsidies may further lead to emergence of negative externalities as the major beneficiaries of the subsidies are largely confined to the rural elites and distributed in ways that undermine private input suppliers, hence further affecting the social welfare (FAO, 2012). Therefore, the FAO report suggests that the agricultural subsidies may at large be a political tool but they are not the best use of public funds and hence their use must be limited.

A general consensus that has been ensued for years is that the failure of markets to provide public goods implies that the government should step in to supply them (Anomaly, 2013). However, this is a wrong assumption to work with. Instead, most economists have never advocated for direct government intervention as the first option to produce public goods. As Hal Varian points out that,

'the standard theory of public goods doesn't call for government intervention – it just says that when public goods are present, simple markets won't achieve efficient outcomes. Conventional economic theory is mute on the question of whether there is any other mechanism that will improve upon the market (Varian, 1993: 545).'

Further, Coase also challenged the dominant view of policy intervention. In his argument he writes, *“The government is, in a sense, a super-firm (but of a very special kind) since it is able to influence the use of factors of production by administrative decision. The government is able, if it wishes, to avoid the market altogether, which a firm can never do. Furthermore, the government has at its disposal the police and the other law enforcement agencies to make sure that its regulations are carried out……*

It is clear that the government has powers which might enable it to get some things done at a lower cost than could a private organisation (or at any rate one without special governmental powers). But the governmental administrative machine is not itself costless. It can, in fact, on occasion be extremely costly………

All solutions have costs and there is no reason to suppose that government regulation is called for simply because the problem is not well handled by the market or the firm. Satisfactory views on policy can only come from a patient study of how, in practice, the market, firms and governments handle the problem of harmful effects (Coase,1960)*.”*

Two of the most commonly observed mediums to privately produce public goods are: Charity and Assurance Contracts (Anomaly,2013). Private charities have been successful in providing public goods like health, education, environment and sustainability. Either produced for selfless purposes or for fame, public goods can also be transformed into impure public goods by creating exclusion mechanisms for those who don’t contribute. For instance, a sports complex can be gated only for those who acquire its membership. Similarly, another means to provide public goods is of ‘Assurance Contracts’. One of the main reasons of deterrence among individuals or group of individuals from providing public goods is the ‘free rider problem’, as it deters the willing individuals from paying as they fear others will not contribute enough. Therefore, suitable for local public goods which are not consumed by many people, conditionally binding assurance contracts can solve this issue (Schmidtz,1987). In assurance contracts a willing individual pledge to contribute for a public good and if enough others make the same pledge by a specific date, then the action for providing the same goes ahead. A firm can charge a fee for acting as a coordinator and underwriting contracts to help willing individuals bind together and direct their efforts. However, as the number of people required to produce a public good increase, the transaction cost might become a constraint. Thus, assurance contracts might not be successful in providing large-scale public goods like environment protection etc.

However, despite of the possibility of private production of public goods, the government still plays a crucial role in form of creation and enforcement of legal environment and incentive structure (Anomaly,2013). This indirect provision of public goods by the government often holds much greater importance as it further facilitates individuals to participate in producing public goods.

Hence, the government can play a major role in provision of public goods in the agricultural sector. The administration could participate directly through expenditure on infrastructure, credit availability and subsidies in areas with maximum social returns. Or, they can provide public goods indirectly by creating a market structure (through taxation on negative externalities or well-defined property rights to name a few) that incentivizes private players to invest.

Agricultural Policy in India –

Since independence, the policy makers have implemented several policies with an objective to reform the agriculture and allied sector of the country, ramp up the rural infrastructure and improve rural economy. These policies have been majorly categorized into four key phases, namely, the ‘Pre-Green Revolution Period’, ‘Green Revolution Period’, ‘Post-Green Revolution and the ‘Economic Reform Period’ (Arora,2013).

While the first phase that stretched from 1947 to the mid-sixties, primarily focused on institutional changes and development of basic irrigation and power infrastructure so as to limit dependency on rainfall. The period has also been particularly known for its land reforms like abolishment of the zamindari system, ceiling on landholdings size, redistribution of idle land to underprivileged rural people etc. so as to ensure rural equity in rural society. The second phase (1965-1980) on the other hand, is known for bringing in a structural shift in Indian agriculture system from conventional farming to commercialized farming. Known as the ‘Green Revolution Period’, it is credited for improving the agriculture productivity through introduction of GM and High Yielding Variety (HYV) seeds (especially for wheat and rice), increase in the use of fertilizers and extension of banking and credit facilities through NABARD for instance. These two decades also witnessed a spurt in adoption of technology driven and machinery-based farming and establishment of agricultural universities which focused on R&D. These factors helped India to achieve self-sufficiency in food grains which was considered as a major feat as agriculture imports constituted a major share of imported goods. However, majority of the progress was limited to the well-irrigated areas like the Gangetic plain and on cash crops like rice and wheat.

The third phase (1980-1991), however, expanded the benefits of commercialised farming to drier areas through diversification of the agriculture sector. As farmers suffered from limited income stream, the policy encouraged adoption of alternative employment opportunities like poultry, vegetables, fruits, milk etc. for improvement in standard of living. This phase also witnessed a spurt in investment by farmers and an increase in revenue expenditures in subsidies towards agriculture sector, while the public sector investment in real terms for infrastructure development started declining (Tripathi and Prasad,2009). Finally, in 1991 as the Indian economy opened its market to rest of the world and became a member of WTO and several other bilateral and multilateral agreements, all the sectors prevalent in the country came in terms with the new regulations that the trade accords brought in. The agriculture and allied sector in particular, witnessed a fall in government intervention, introduction of liberalized trade, hence providing new markets (domestically as well as in rest of the world) for their produce and lastly a rise in stiff competition from the cheap and preferable imports of raw and processed food products. The latter however proved to be a major challenge for policy makers as it had the potential to severely disrupt the Indian agricultural output and hence, impede the growth of the rural economy and also affect the earnings of the small and marginal farmers. Therefore, the ‘National Agricultural Policy (NAP),2000’ was implemented by the Indian Government so as to improve efficiency of the agriculture sector and enable it to prosper in a market-based economy (Arora,2013). The key objectives of the policy were:

- To attain a growth rate of 4% per annum through efficient use of natural resources.
- To attain an equitable and a technologically, environmentally and economically sustainable growth.
- To attract private investment in agro-food sector as well as in rural infrastructure development, in line with the steadily falling public investment, so as to maintain long-term growth and relative competitiveness of the sector.

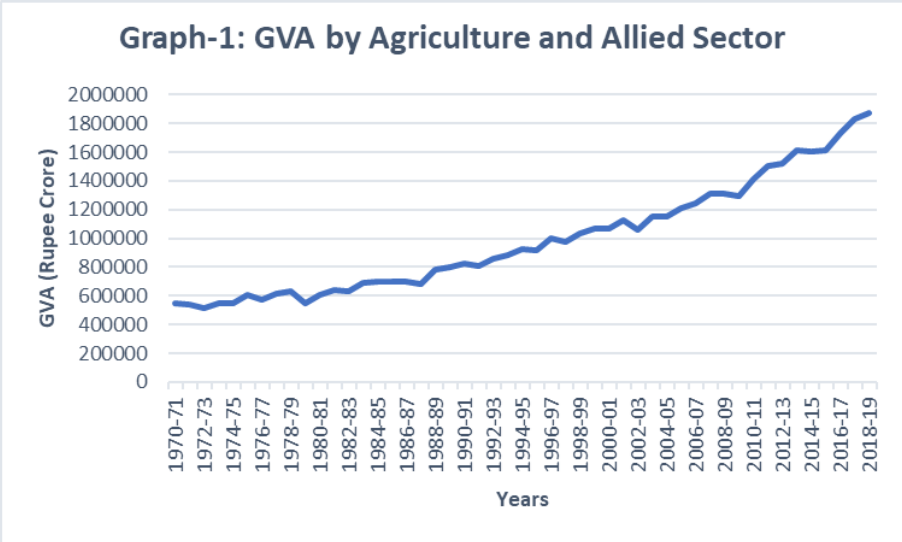
While several of these framed policies have been successful, but due to the absence of basic infrastructure and limited public investment in several regions (especially the north-east and eastern parts of India), the benefits derived from these initiatives have not been uniform across the nation.

Policy Implication –

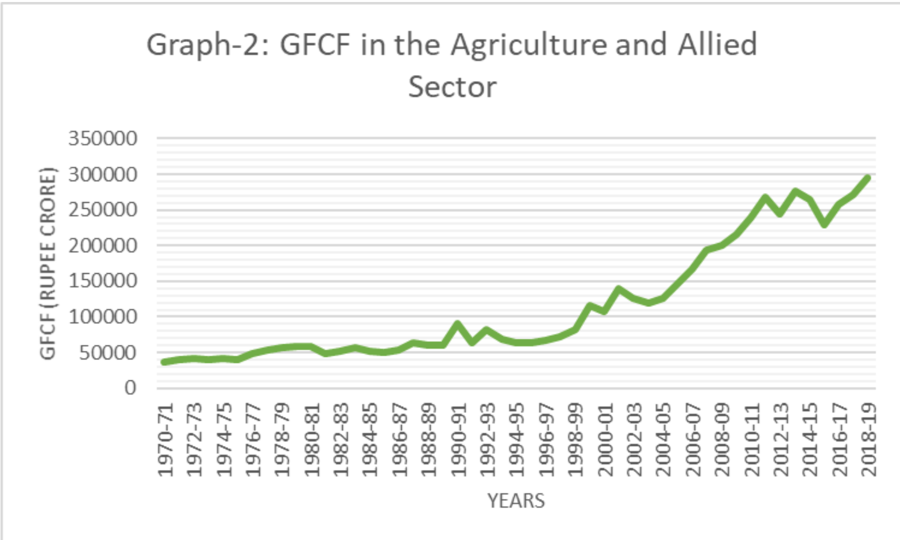
The agriculture and allied sector are made up by key four industries, namely 'Agriculture', 'Forestry and Logging' and 'Fishing' (Statistics Manual, MOSPI). Further, the agriculture industry in itself comprises:

- Crops, namely foodgrains (like cereals, pulses and oilseeds) and non-foodgrains (like potato, onion, tea, coffee, rubber, tobacco, cotton etc).
- Livestock, which is used for dairying, breeding and draught purposes. It is classified as a part of machinery and treated as fixed assets for accounting purposes.

Over the years, policy makers have implemented several agricultural reforms that have helped to improve the productivity of the agricultural and allied sector. However, still the agriculture industry accounts for majority of the contribution to the output of the agriculture and allied sector. For instance, in 2018-19 as per National Account Statistics 2020, the agriculture industry (that is, crops and livestock) made up about 84.93% of the gross value added (GVA) by the agriculture and allied sector to the economy. In addition, crops solely held about 56.3% of the GVA by the sector. Therefore, to understand the policy implications of the agricultural policy, the performance of the agriculture and allied sector has been presented at 2011-12 prices so as to account for inflation.



Source: Author's calculation based on National Account Statistics,2020 and Back-Series of National Accounts (Base 2011-12)



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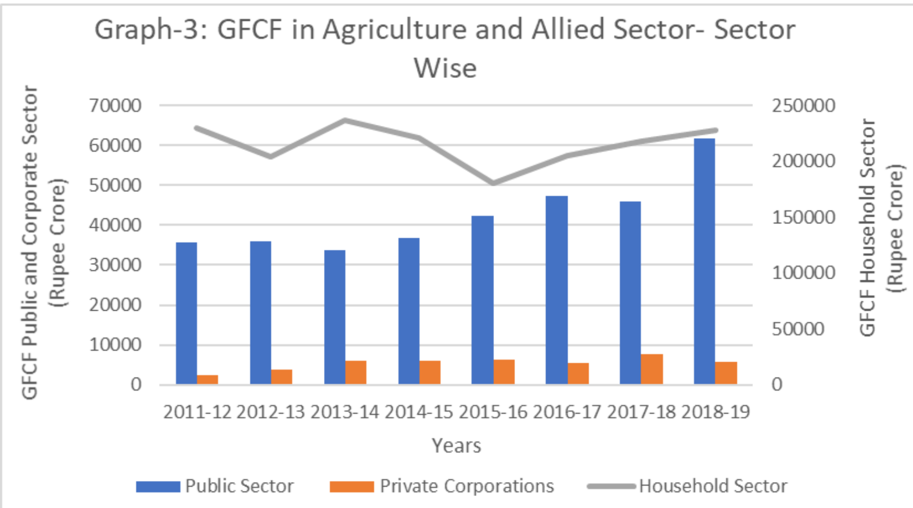

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The gross value added by the sector has seen an exponential growth over the years. In 1970-71, the value addition had been at about Rs 5,45,462 crore which has grown over to approximately Rs 18,72,340 crore in 2018-19, a growth of about 243.25%. However, on a closer look it can be seen that for the first two decades till late 1980's the growth in output value had been much or less constant but grew rapidly post 1990's and further accelerated after 2000-2001. This surge in gross value output corresponds to the impact of policies like green revolution and diversification of income stream in the industry from cash crop cultivation to dairy farming, horticulture etc, carried out in the early '80s, followed by the periods of post-liberalisation that helped in capital inflow to otherwise labour surplus industry.

During the same timeline from 1970-2019, the total level of investment directed towards the agriculture industry grew by almost eight times from Rs37,147 crores approx. in 1970-71 to about Rs 2,95,585 in 2018-19. However, till mid-2000's the gross fixed capital formation had been slower and only picked up pace since then. Further, it can be deduced that the household sector dominates the overall investment directed towards the agricultural and allied sector, followed by the public sector and a meagre inflow of capital investment from the private corporate sector. As per 2018-19, the household sector constituted approximately 77% (about Rs 2,28,168 crore) of the total gross fixed capital formation in the industry, while public sector had a share of about 21%, that is, Rs 61,810 crore (National Account Statistics, 2020). While, the total private sector investment in 2018-19 valued only Rs 5,608 crore and acquired a share of just 2%. However, neither of the household sector or private sector has witnessed a significant rise in the rate of capital formation between 2011-2019 and the public investment only saw a spurt of about 34% in 2018-19, all of which denotes a stagnation in capital formation in the agriculture and allied sector. This is a matter of utmost concern and requires requisite deliberation from the policy makers. Therefore, while the majority of the investment in agriculture industry is from savings of the agricultural households, the participation of the corporate sector still lags behind possibly due to the lack of incentive.

Agriculture Orientation Index –

Similar to India, the global figures have also suggested a shift in orientation of the government across the nations from agricultural sector to non-agricultural sectors (Wielechowski,2019). Between 2003 and 2017 based on world data, while on average the relative share of agriculture in GDP grew by 50% from 4.04% to 6.15%, the share of agriculture and allied sector in total government expenditure grew from 1.46% to 1.86% only. A better assessment of the level of public expenditure in agriculture is provided by the 'Agriculture Orientation Index', a currency-free index developed by the Food and Agriculture Organisation (FAO) of the United Nations. The index was developed to rank the performance of the nations of their efforts to achieve 'Goal 2: End hunger, achieve food security and improved nutrition and promote sustainable agriculture', one of the 17 Sustainable Development Goals adopted by the United Nations that are aimed to be achieved by 2030 (UN SDGs,2020). FAO defines the AOI as 'the Agriculture share of Government Expenditure, divided by the Agriculture value added share of GDP', that is,

$$AOI = \frac{Agriculture\ Share\ of\ Governement\ Exenditures}{Agriculture\ Value\ Added\ Share\ of\ GDP}$$

Where;

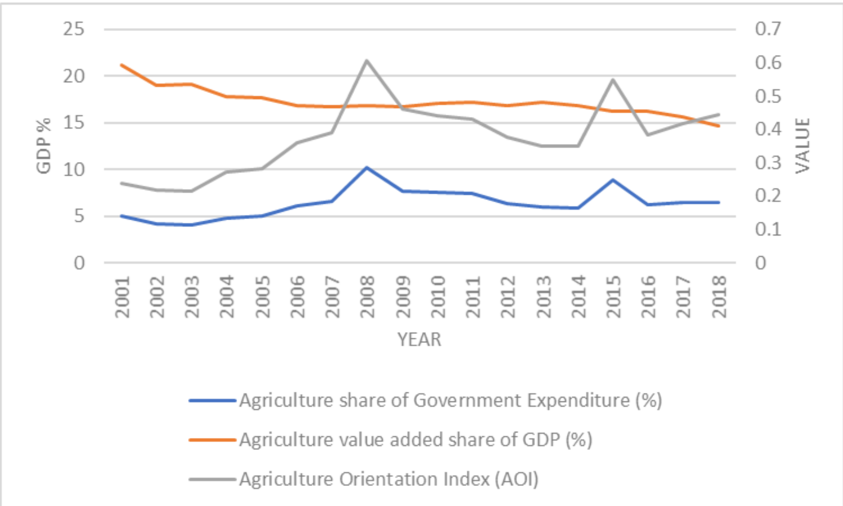
$$Agriculture\ Share\ of\ Goverment\ Expenditure = \frac{Central\ Government\ Expenditure\ on\ Agriculture}{Total\ Central\ Government\ Expenditure} * 100$$

And;

$$Agriculture\ Value\ Added\ Share\ of\ GDP = \frac{Agriculture\ Value\ Added}{GDP} * 100$$

The index is known for its capability to explicitly explain the orientation of the government towards agriculture sector. If the AOI is greater than 1, then it reflects a higher orientation towards the agriculture sector, which receives a higher share of government spending relative to its contribution to economic value-added. An AOI less than 1 reflects a lower orientation to agriculture, while an AOI equal to 1 reflects neutrality in a government's orientation to the agriculture sector. Based on the definition of AOI, studies have found a fall in AOI from 0.36 in 2003 to 0.26 in 2017 (Wielechowski,2019).

In case of India, the agriculture and allied sector is highly underinvested as represented by the 'Agriculture Orientation Index'. Between 2001and 2018, the share of expenditure on agriculture by central government grew by 29% (5% of total expenditure in 2001 to 6.5% in 2018). During the same period, the share of agriculture and allied sector in GDP reduced from 21% in 2001 to 14% in 2018. However, agriculture's contribution to GDP in 2018 was still twice the central government's expenditure on agriculture. This is a clear indication of the state of underinvestment in agriculture and allied sector in the country.



Source: Author's calculation based on UN SDG's Indicators Database (2020)

In India, wherein about 21% of the population lives below the national poverty line (SDG Progress Report, 2020) and 69% of the population lives in rural areas (Agriculture Statistics,2019), achievement of food security and eradication of malnourishment becomes a major policy commitment for the government. Further, in rural areas majority of the workforce is engaged in agriculture sector. However, the income earned by agricultural households is highly skewed across the nation as well as within the sector based on landholdings size (NSS Report, 2012-13). The average monthly income earned by the workers in agricultural sector was Rs 6,426 in 2012-13 but it varied based on the landholding size. While, a farmer with a landholding of 0.41-1 hectare earned only Rs5,247 per month on average, on the other hand, a household with a landholding of more than 10 ha had an average monthly income of about Rs41,388. Similarly, the states which had been able to reap the benefits of green revolution, adopt mechanized farming and provide a market structure had a higher average monthly income than states who lagged behind. Hence, states like Punjab, Haryana and Kerala saw an average monthly income of Rs 18059, Rs 14434, Rs11888 respectively, while, Uttar Pradesh, Bihar and Odisha earned an average monthly income of only Rs4923, Rs3980 and Rs4976 respectively. Therefore, expenditure equally by government and private sector can enhance agricultural productivity and direct efforts for sustainable agriculture.

The ‘Agriculture Orientation Index’ as SDG indicator for goal 2 acts as a great tool to monitor the commitment of the countries towards agriculture and achievement of food security and proper nutrition. In 2018, India had an AOI of 0.45 which means "For every unit spent of the of total central government’s budget, agriculture gets 45% of what it should obtain if allocation was according to contribution to GDP". It is therefore evident that India has a lower orientation to agriculture and has to direct more revenue towards the sector so as to improve its standing in SDG goals.

Empirical Study –

While, in developing economies like India, Nigeria and Pakistan, a structural shift from agriculture sector to non-agriculture sector is inevitable, but reducing the government expenditure in rural public goods in general and agriculture sector in particular relative to its contribution in economy in the absence of /limited private investment, only hampers agricultural productivity, poverty reduction and growth of the rural economy where majority of the population in these countries reside. As private sector typically under-invests in agriculture and allied sector due to the presence of market failures, there is a need for a significant and rightly prioritised increase in agricultural spending by the government which is efficiently utilised (Singh et al.,2015). If adopted, this increase in spending can not only help to improve rural economy and attract private investment but most importantly achieve the goal 2 of SDG.

As research indicate a positive and significant impact of increase in agriculture output on economic growth, especially in developing countries (Chandio et al.,2016); several other studies have been conducted to analyse various variables that affect agricultural and allied sectors output, so as to further boost up the sector’s output. Government expenditure and cultivated area (Ayoub and Mivumbi,2019) have often been found as the most significant variables that have a positive impact on agriculture productivity in the long-run. Sebastian et al. (2018) in their paper ‘Impact of Government Agricultural Expenditure on Agricultural Productivity in Nigeria’ concluded that government expenditure of up to 2 lags had a positive and significant impact on agriculture output, while average annual rainfall was significant at lag 1 with a positive coefficient.

However, an interesting result was that the population growth was the most significant factor in the study and had a negative coefficient. The negative coefficient implied that there was a slower adoption of mechanized farming due the presence of abundant labour force leading to lower productivity and highlighting the need for higher government investment. However, several studies have also iterated the fact that the expenditure on agriculture and allied activities and agriculture output could have a negative relationship in the long-run (Utpal et al.,2018). Rather, expenditure on education, rural development and transport have been found to have a significant impact on agriculture output with a positive coefficient. This is because, Utpal et al. (2018) points, an educated farmer is in a better position to adopt improved technologies, rural development schemes boost basic infrastructure like banking and credit facilities that help farmers to improve productivity by using better inputs and better transport facilities for instance provide the agriculture produce an access to urban markets where it can be sold at a higher price respectively.

In developing economies, studies have further shown that the impact of public expenditure on agricultural output varies with the purpose of the expenditure incurred (Manyise et al.,2015). Capital Expenditure on agriculture has been found to have a positive and significant impact in the short-run and even in long-run. These findings are consistent with the economic theory that the public capital expenditure creates an environment conducive for investment and should crowd-in private investment, hence, increasing economic activity and agricultural growth (Barro,1990). Further, Manyise et al. (2015) study finds that non-agricultural expenditure like on health or transport services also show a positive and significant impact on agricultural growth, probably due to its distribution effect. However, recurrent agricultural expenditure showed a negative relationship to real agriculture GDP, which implies that current expenditure like subsidies and wages are non-productive and yet most of the developing economies contribute more than eighty percent of budgetary resources to them.

Finally, in context of the Indian economy, a positive and significant relationship between public and private sector investments in the agricultural and industrial sector indicates a significant crowding-in impact of public investment on private investments (Mani et al.,2011). Also, public and private investments have been found to have a significant and positive influence on agricultural productivity (Saini et al., 2010). Further, since independence structural changes in the economy have led to a shift in the relative contribution of factors in the growth of agricultural sector (Tripathi and Prasad,2009). Prior to the ‘Green Revolution Period’ in 1965, expansion of area under cultivation due to land reforms was the main source of growth for agriculture sector. However, post-1965 the contribution of increased land area has declined and increased productivity became the main source of growth in agricultural production. This can be due to better access to capital, HYV seeds and fertilizers, diversification to high-value commodities like poultry, flowers etc and increased involvement of private sector brought in over years after the Green Revolution. The link between institutional credit to agriculture and agricultural GDP has been found to be weak and misplaced (Narayanan, 2015). The author suggests that though credit has played its part in supporting purchase of inputs but this effect has not fully translated into agricultural GDP growth. While, other papers suggest a positive and statistically significant impact of agricultural credit on agricultural output (Das et al, 2009).

Methodology

The study focuses to measure the change in agricultural output and identify the relative contribution of different inputs. Several approaches can be used to address the question, namely, the index numbers approach, nonparametric approach and econometric estimation of production relationships (Zepeda,2001). Zepeda (2001) points out, since the index numbers and nonparametric approach are not statistically derived, therefore they cannot be statistically validated, which makes the model less reliable. However, models developed through econometric approach are statistically derived which enables the model to be tested for reliability by undertaking hypothesis testing and calculation of confidence intervals. Further, these models explicitly measure the marginal contribution of each input on the aggregate agricultural output which can enhance the study by highlighting the impact of each explanatory variable on the dependent variable. The impact of inputs like capital investment can often affect the production in more than one year, as Chavas and Cox (1992) found that 30 years are required to fully capture the effects of public research expenditures in US agricultural productivity. Therefore, by considering time lags in the data, the efficiency of the model to predict agricultural output can be enhanced. Although, a time series analysis requires extensive data sets but as it has the ability to assess the pattern of change over time in the dependent variable, therefore, a time-series analysis has been considered for the study.

Data and Model Specification

The yearly data for time series analysis has been collected for the period 1970-71 to 2015-16 through secondary sources like various issues of National Account Statistics and Agricultural Statistics at a Glance published by Government of India and Handbook of Statistics on Indian Economy issued by the Reserve Bank of India.

Due to the prevalence of disaggregated data sets for several variables, four key models can be developed thereby giving varying results as explained later in the paper. Therefore, the study uses triangulation method so as to assure validity of the findings of the qualitative study (Guion et al,2011).

The four models adopted are linear models wherein the variables are expressed in terms of per million hectares of the total cropped area as illustrated below:

Model 1 –

$$\mathrm{GVA} = \beta_0 + \beta_1 \mathrm{PerCapita\_Foodgrains} + \beta_2 \mathrm{GIA} + \beta_3 \mathrm{Fertiliser\_cons} + \beta_4 \mathrm{GFCF\_Pri} + \beta_5 \mathrm{GFCF\_Pub} + \beta_6 \mathrm{Institutional\_Credit\_PA} + u_t$$

Model 2 –

$$\mathrm{GVA} = \beta_0 + \beta_1 \mathrm{GFCF\_Pub} + \beta_2 \mathrm{GFCF\_Pri} + \beta_3 \mathrm{GIA} + \beta_4 \mathrm{Fertiliser\_Cons} + \beta_5 \mathrm{Instituitonal\_Credit\_FA} + u_t$$

Where notations correspond to the following variables:

Notations	**Variables**
GVA	Gross value added by the agricultural sector at 2011-12 prices (in Rupee crores)
GFCF_Pub	Gross fixed capital formation by public sector in agricultural sector (crops + livestock) divided by total cropped area (in million hectare) at 2011-12 prices (in Rupee crores)
GFCF_Pri	Gross fixed capital formation by the private sector in agricultural sector (crops + livestock) divided by total cropped area (in million hectare) at 2011-12 prices (in Rupee crore)
GIA	Gross irrigated area (in million hectare)
Fertiliser_Cons	All India fertiliser consumption in terms of nutrients (N, P & K), in thousand tonnes divided by total cropped area (in million hectare)
Institutional_Credit_PA	Total (short-term and long-term) direct institutional credit for agriculture and allied activities (in Rupee crores), deflated to 2011-12 prices using Wholesale Price Index- Primary Articles (WPI-PA) divided by total cropped area (in million hectare)
Institutional_Credit_FA	Total (short-term and long-term) direct institutional credit for agriculture and allied activities (in Rupee crores), deflated to 2011-12 prices using Wholesale Price Index- Food Articles (WPI-FA) divided by total cropped area (in million hectare)
PerCapita_Foodgrains	Per capita net availability of food grains per annum in India (kilograms per year)

The dependent variable, gross value added by agriculture (i.e., crop and livestock) industry, has been used as a proxy for the gross value added by the agriculture and allied sector. Similarly, the explanatory variable - gross fixed capital formation by public sector and private sector respectively - correspond to the level of capital expenditure in the agriculture industry which is used as a proxy for overall level of investment in the agriculture and allied sector. Further, the investment by private sector implies the overall investment by the private corporate and household sector.

The primary reason of picking agriculture industry as a proxy for the agriculture and allied sector is due to its overall dominance in the sector, as explained before under the heading 'Policy Implication'. Finally, all the aforementioned variables are picked at constant 2011-12 prices and denominated in rupee crores.

The direct institutional credit flow to the agriculture and allied sector is the sum of credit directed towards the sector by scheduled commercial banks (SCB's), regional rural banks (RRB's) and co-operatives. The institutional credit is also expressed in rupee crores. As the values were represented at nominal prices, they were deflated by using the Wholesale Price Index (WPI) as a deflator at 2011-12 prices.

The different wholesale price index series for different base years were linked using the arithmetic conversion method which assumes that there exists a linear relationship between the indices in the old series (Y) and those in the new series (X), i.e., Y=cX, where c is the conversion factor. This factor is calculated as the average value of index in the base year in old series divided by the average value in the base year in the new series (generally 100). That is,

$$c = \frac{\bar{X}}{\bar{Y}}$$

Based on the WPI series with base year 2011-12, the institutional credit to the agricultural sector is then calculated in real terms. The calculation has been laid out in detail in appendix 1 and 2. The linking method approached is selected based on the suggestion of Compilation Manual of Ministry of Commerce and Industry, Government of India.

Model 3 –

$$\mathrm{GVA} = \beta_0 + \beta_1 \mathrm{PerCapita\_Foodgrains} + \beta_2 \mathrm{GIA} + \beta_3 \mathrm{Fertiliser\_cons} + \beta_4 \mathrm{GFCF\_Pri} + \beta_5 \mathrm{GFCF\_Pub} + \beta_6 \mathrm{Institutional\_Credit\_PA} + \mathrm{u_t}$$

Model 4 –

$$\mathrm{GVA} = \beta_0 + \beta_1 \mathrm{GFCF\_Pub} + \beta_2 \mathrm{GFCF\_Pri} + \beta_3 \mathrm{GIA} + \beta_4 \mathrm{Fertiliser\_Cons} + \beta_5 \mathrm{Instituitonal\_Credit\_FA} + \mathrm{u_t}$$

Where the notations correspond to the following variables:

Notations	**Variables**
GVA	Gross value added by the agricultural and allied sector at 2011-12 prices (in Rupee crores)
GFCF_Pub	Gross fixed capital formation by public sector in agricultural and allied sector divided by total cropped area (in million hectare) at 2011-12 prices (in Rupee crores)
GFCF_Pri	Gross fixed capital formation by the private sector in agricultural and allied sector divided by total cropped area (in million hectare) at 2011-12 prices (in Rupee crore)
GIA	Gross irrigated area (in million hectare)
Fertiliser_Cons	All India fertiliser consumption in terms of nutrients (N, P & K), in thousand tonnes divided by total cropped area (in million hectare)

Institutional_Credit_PA	Total (short-term and long-term) direct institutional credit for agriculture and allied activities (in Rupee crores), deflated to 2011-12 prices using Wholesale Price Index- Primary Articles (WPI-PA) divided by total cropped area (in million hectare)
Institutional_Credit_FA	Total (short-term and long-term) direct institutional credit for agriculture and allied activities (in Rupee crores), deflated to 2011-12 prices using Wholesale Price Index- Food Articles (WPI-FA) divided by total cropped area (in million hectare)
PerCapita_Foodgrains	Per capita net availability of food grains per annum in India (kilograms per year)

In models 3 and 4, unlike the previous models the dependent variable 'Gross Value Added' and the explanatory variables 'Gross Fixed Capital Formation' by the public and private sector respectively correspond to the entire agriculture and allied sector, that is, the data set also includes the output level and amount invested for the forestry and fishing sector as well along with the crop and livestock sector. This is done so as to ensure that the variables and thereby estimates are not underestimated and provide results for the entire industry rather than the known predominant sectors.

Econometric Model

The study implements three econometric procedures so as to obtain the results. The first step is to check for stationarity of the variables which is achieved through Augmented Dickey-Fuller (ADF) test and Phillips-Perron test. The next step of Johansen Cointegration Test helps us to determine the long-run relationship between gross value added by agricultural sector and the level of investment in the agricultural sector. Finally, in the third step, Vector Error Correction Model (VECM) is applied to obtain the short-run estimates of parameters and also determine the coefficients of error correction model. Further, these coefficients are used to examine the adjustments made by the parameters to reach long-run relationship.

Stationarity Test –

A time series is said to be stationary when its mean, variance and covariance remain constant over time. Further, the value of covariance depends on the gap between two observations and not the reference period at which covariance is computed. Therefore,

$$\text{Mean: } E(Y_t) = E\left(Y_{t+j}\right) = \mu$$

$$\text{Variance: } \mathrm{Var}(\mathrm{Y_t}) = \mathrm{Var}\left(Y_{t+j}\right) = \sigma^2$$

$$\text{Covariance: } Cov\left(Y_t, Y_{t+j}\right) = Cov\left(Y_s, Y_{s+j}\right) = \gamma_j$$

This implies that the mean and variance do not change over time and γ_j, the covariance at lag j, depends on the observations between periods 't' and 't+j'. Also, the covariance is identical at all the observations separated by lag j. Hence in the long-run, such a time series tends to revert back to its mean (called mean reversion) and the fluctuations around this mean have a constant amplitude. However, in a non-stationary series, the mean and variance tend to vary over time. This implies that the series does not revert back to its mean value, that is, the shocks like a trend or drift tend to stay. Non-stationarity, therefore, has serious statistical consequences. It generates biased autoregressive coefficients of the variable and a flawed confidence interval, leading to an incorrect forecast estimates and series interpretation.

Therefore, to establish a long-run relationship it is imperative to have a stationary time-series. This can be achieved by differencing a non-stationary series till it becomes stationary. The number of times a non-stationary series is differenced to make it stationary is known as 'Order of Integration'. To test for the stationarity of the variables and determine its order of integration, Augmented Dickey-Fuller test (ADF) is used (Gujarati and Porter, 2009: 754-759). The test is conducted on the following regression with autoregressive coefficients of up to lag p,

$$\Delta y_t = \mu + \alpha t + \gamma y_{t-1} + \sum_{i=1}^{p} \beta_i \Delta y_{t-i} + \varepsilon_t$$

Where, μ is the intercept term, αt is the trend term and ε_t is the pure white noise error term and $\Delta y_{t-1} = y_{t-1} - y_{t-2}, y_{t-2} = y_{t-2} - y_{t-3}$ and so on. The high-order lags accounts for that the error term is not serially correlated. Hence, the ADF test checks for the null hypothesis that the variable has a unit root ($\gamma = 0$), that is, it is not stationary against the alternative hypothesis that the variable is stationary ($\gamma < 0$). Finally, the study uses Akaike Information Criterion (AIC) to select the optimal lag length of the variables for the ADF test. This is because in a more parsimonious model that may be selected based on Schwarz Bayesian Criterion (SBC), there may be some risk of lingering unit roots which can lead to biased results.

However, the ADF test low power in certain circumstances like for near unit roots and for small samples. Further, the assumption that the error term is white noise is always not necessary. Therefore, the Phillips-Perron test helps to account for any serial correlation or heteroskedasticity coming out of errors. Hence, PP test has also been used to test for the stationarity of the variables.

Johansen Cointegration Test and Vector Error Correction Model (VECM) –

Even if the one or more variables are non-stationary, it doesn't mean that there does not exist a relation between them. The cointegration test helps to establish a long-run equilibrium relationship among the variables. These I(1) variables are said to be cointegrated, if in the long-run there exists at least one linear combination of these variables that is stationary. Hence, even if the relationship between variables in the short-run may be in disequilibrium but if the variables are cointegrated then long-run equilibrium exists (Gujarati and Porter, 2009: 762). This adjustment process to reach long-run equilibrium is examined through the error correction term represented in the Vector Error Correction Model (VECM), a VAR that accounts for non-stationary series that are known to be cointegrated. The VECM for a vector Y can be represented in the matrix form as:

$$\Delta Y_t = C + \sum_{i-1}^{n} \beta_i \Delta Y_{t-i} + \sum_{i=0}^{n} \delta_i \Delta X_{t-i} + \varphi Z_{t-1} + e_t,$$

where Z represents the 'error correction term' which shows the impact of the deviation from long-run equilibrium in the previous period on the short-tun estimates of the dependent variable; and φ is the speed of adjustment, i.e., the speed at which Y returns to equilibrium after a change in X. The cointegrating equation is represented as:

$$Z_{t-1} = ECT_{t-1} = Y_{t-1} - \beta_0 - \beta_1 X_{t-1}$$

The study uses Johansen Cointegration Test to determine the existence of cointegration and the number of these cointegration relationships. The Johansen methodology is simply based on the idea of estimating the rank of the matrix β_1 which cannot exceed n, the number of variables in the model. Hence,

- If rank(β_1) = 0 : No cointegration
- If rank(β_1) = n : Full rank, all variables are I(0)
- If 0< rank(β_1) = r < n : Less than full rank, there are r independent cointegration relationships.

The value of r, number of independent cointegration relationships, is determined through the following Johansen statistics:

1) The Trace Statistic for each rank, r: The null hypothesis is that the rank is at most r, versus it's strictly greater.
2) The Maximum Eigenvalue Statistic for r: The null hypothesis is that the rank is exactly r versus the alternative, that is, r+1.

Hence, by obtaining the number of cointegrating equations through Johansen Cointegration test and constructing an Error Correction Model (ECM), the long-run relationship between variables can be established and the adjustment process in short-run examined.

Results and Interpretation

Model 1 –

For analysis purpose, we first consider the situation wherein institutional credit to agricultural sector has been calculated through Wholesale Price Index – Primary Articles. As primary articles even consist of non-agricultural goods like minerals, crude and petroleum gas, the value of credit may be inflated. However, as the major constituent in changes in value of price index is categorized by food articles, therefore, the weightage of inputs other than food articles in calculation of WPI(PA) can be overlooked. The aforementioned statement is further validated by the fact that in the 2011-12 WPI series while primary articles was assigned a weight of 22.618, food articles comprised a weight of 15.256 in primary articles (Manual on Wholesale Price Index). Hence, the linear model that has been developed is:

$$\text{GVA} = \beta_0 + \beta_1\text{PerCapita\_Foodgrains} + \beta_2\text{GIA} + \beta_3\text{Fertiliser\_cons} + \beta_4\text{GFCF\_Pri} + \beta_5\text{GFCF\_Pub} + \beta_6\text{Institutional\_Credit\_PA} + u_t$$

The Augmented Dickey-Fuller (ADF) and Phillips-Perron test for non-stationarity brings out the following results-

Variables	**ADF**		**PP Test**	
	Level	First Difference	Level	First Difference
GVA	-1.488530 (0.8186)	-10.51043** (0.00)	-2.119626 (0.5212)	-18.65479** (0.00)
GFCF Pub	-1.266175 (0.8836)	-6.037262** (0.00)	-1.514764 (0.8097)	-6.090459** (0.00)
GFCF Pri	-2.699902 (0.2419)	-4.118331** (0.0131)	-2.131181 (0.5150)	-6.850827** (0.00)
GIA	-4.072230 (0.0136)	-5.039909* (0.0010)	-3.823067 (0.0243)	-8.528190* (0.00)
Fertiliser Cons	-3.978898 (0.0167)	-4.601280* (0.0039)	-2.972899 (0.1509)	-4.446544** (0.0049)
Institutional Credit PA	-1.194513 (0.8970)	-1.702535 (0.7288)	2.234386 (1.00)	-6.533358** (0.00)
PerCapita Foodgrains	-2.832595 (0.1939)	-5.488529** (0.0003)	-5.773997* (0.0001)	-17.04319* (0.00)

Note: * and ** indicate significance at 1% and 5% level respectively. The parentheses show the p-values. Trend and constant included.

Source: Computed by author using E-views 11

The unit roots test shows that all the variables included in the model are stationary at first difference, i.e., of I(1) order of integration either at 1% or 5% level of significance. The ADF test rejects the null hypothesis that the variable under consideration has a unit root at first difference for all except institutional credit, however, the PP test rejects the same at 5% significance level. This is because the Phillips-Perron test accounts for any disturbance in the error term, so it would have corrected any disturbance that would have been crept in while transforming the nominal values of institutional credit to real terms using WPI (Primary Articles).

Based on our results of non-stationarity, we proceed to test the model for presence of cointegration. For that we first develop a VAR model and derive best lag that fits the model before proceeding towards cointegration test.

The VAR model assumes the constant to be an exogenous variable and treats rest of the variables as endogenous. In order to determine the optimal lag length for VAR, we use the Lag Length Criteria and reach a conclusion based on the following Information Criterions: AIC (Akaike Information Criterion) and SC (Schwarz Information Criterion). As using lags reduces degree of freedom, therefore to maintain a parsimonious model for a sample size of 45 observations in VAR, 3 lags are included in the lag order selection criteria. The results thus obtained are:

Lag	**AIC**	**SC**
0	81.58484	81.87154

1	71.47433	73.76799*
2	70.68908	74.98968
3	69.47357*	75.78113

* indicates lag order selected by the criterion

Source: Computed by author using E-views 11

As seen from the lags-length criteria, the information criterion SC suggest one lag for the optimal number of lags in the model. While, AIC suggests three as optimal lag. Since, SC imposes a harsher penalty than AIC for adding new variables, i.e., it selects a more parsimonious model, hence, the lag selected by SC and consequently the model developed can be relatively more accurate than that of AIC. Therefore, we select 1 lag order for the VAR model. Moving forward, we now establish the presence of cointegrating relationship between the variables through Johansen Cointegration Test.

Consider the lag length criterion establishes a VAR(p) model, this implies that we obtain a VEC(p-1) model since one lag is lost on rewriting the VAR by differencing to derive VECM. Hence, our VECM would be of lag order 0, i.e., there are no lags of the first differenced endogenous variables and only one lag in the level series.

Having specified the VECM model, we now proceed to determine the presence of cointegration. If the cointegrating relationship exists then we can say that there exists a long-run equilibrium among the variables and proceed forward with the VECM(0) model. However, if we find no presence of a cointegrating equation, then we perform a standard VAR model in differenced terms at lag order 0. As mentioned before, the study uses Johansen Cointegration Test to check for cointegrating equations with the null hypothesis that there are no cointegrating relationships against the hypothesis that there exists a cointegrating relationship at a lag interval 0. We use the trend assumption mentioned by option 3 that there are linear deterministic trends in levels and the cointegrating equations are stationary around constant means. The test results obtained are specified below:

Unrestricted Cointegration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None *	0.730174	161.1914	125.6154	0.0001
At most 1 *	0.545224	102.2424	95.75366	0.0166
At most 2	0.416206	66.78465	69.81889	0.0852
At most 3	0.374785	42.56531	47.85613	0.1435
At most 4	0.282679	21.43062	29.79707	0.3313
At most 5	0.099923	6.480194	15.49471	0.6387
At most 6	0.037989	1.742810	3.841465	0.1868

Trace test indicates 2 cointegrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Source: Authors' calculation using EViews 11

As seen from the Johansen cointegration test, there exists a long-run relationship between the variables. The trace statistic is significant at 5% for no cointegrating equation. Therefore, we can reject the null hypothesis of no cointegration among the variables against the alternative of at most one cointegration. Moreover, we can reject the null hypothesis of at most one cointegrating vectors versus the alternative of two cointegrating vectors as the trace statistic (102.24) is greater than the 0.05 critical value (95.75). Finally, at r=2 as the p-value (0.0852) is greater than 0.05, the null hypothesis of at most 2 cointegrating equations is not rejected. Hence, we can conclude that in order to determine a long run relationship between the variables, there exists two cointegrating equations.

Therefore, we can proceed with our mentioned VECM model with a lag interval of 0 and two cointegrating relationship among the variables. The results obtained from the VECM (Appendix 3) are represented and interpreted hereby:

The system equation to know the p-values and generate the long-run analysis with gross value added as the dependent variable can be represented as:

$$\begin{aligned}\mathrm{D(GVA)} = {} & \mathrm{C(1)} * (\mathrm{GVA}(-1) - 14087.356 * \mathrm{GIA}(-1) + 3066.021 * \mathrm{FERTILISER\_CONS}(-1) \\ & - 2077.642 * \mathrm{GFCF\_PRI}(-1) - 196.9204 * \mathrm{GFCF\_PUB}(-1) + 182.946 \\ & * \mathrm{INSTITUTIONAL\_CREDIT\_PA}(-1) + 669942.858\,) + \mathrm{C(2)} \\ & * (\,\mathrm{PERCAPITA\_FOODGRAINS}(-1) + 0.579 * \mathrm{GIA}(-1) - 0.885 \\ & * \mathrm{FERTILISER\_CONS}(-1) + 0.418 * \mathrm{GFCF\_PRI}(-1) + 0.174 * \mathrm{GFCF\_PUB}(-1) \\ & - 0.064 * \mathrm{INSTITUTIONAL\_CREDIT\_PA}(-1) - 281.95) + \mathrm{C(3)}\end{aligned}$$

The VECM estimates for short-run analysis with GVA as the target variable are:

$$\mathrm{D(GVA)} = -0.423\mathrm{ect}^1_{t-1} - 2265.041\mathrm{ect}^2_{t-1} + 21793.88$$

And the cointegrating equation (i.e., the long-run model) with GVA as the dependent variable is:

$$\begin{aligned}\mathrm{ect}_{t-1} = {} & 1.000\mathrm{GVA}(-1) - 14087.356 * \mathrm{GIA}(-1) + 3066.021 * \mathrm{FERTILISER\_CONS}(-1) \\ & - 2077.642 * \mathrm{GFCF\_PRI}(-1) - 196.9204 * \mathrm{GFCF\_PUB}(-1) + 182.946 \\ & * \mathrm{INSTITUTIONAL\_CREDIT\_PA}(-1) + 669942.858\end{aligned}$$

Only the long-run coefficient of private investment is statistically significant at 95% confidence level. Hence, we can interpret Rs 1 crore per million hectares of total cropped area rise in private investment as about Rs 2077.64 crore increase in agricultural output on average, keeping other factors constant. Similarly, a Rs 1crore per million hectares of total cropped area rise in public investment seems to cause on average about Rs196.92 crore rise in the gross value added, keeping other factors constant. Interestingly, Rs 1 crore/million hectare of total cropped area increase in institutional credit can be associated with about Rs 182.94 crore fall in gross value added by the agricultural sector on average, ceteris paribus.

Next to interpret the coefficient of error correction term, we estimate an OLS equation using the system equation developed before by applying least square method. The results of the estimated equation with D(GVA) as the dependent variable are:

	Coefficient	Std. Error	t-Statistic	Prob.
C(1)	-0.422569	0.068174	-6.198423	0.0000
C(2)	-2265.041	372.2363	-6.084954	0.0000
C(3)	21793.88	4630.995	4.706089	0.0000

Source: Computed by author using E-views 11

The coefficient of the error correction term (ECT) of GVA variable (shown by C(1)) is negative and statistically significant at 5% and also lies in the desirable range of -1 to

0. This implies that the model is stable and converges to the steady state. Moreover, as values tending to -1 signify a faster speed of adjustment of the system from its previous period disequilibrium towards the long run equilibrium. Therefore, an ECT of -0.423 means that in the short run GVA are adjusted by 42% of the previous year's deviation from the long run equilibrium. In other words, the error correction term of GVA implies that about 42% disturbance in the short-run is corrected each year. This implies that the existing disequilibrium will be reduced to half in about 1.3 years (that is, ln(0.5)/ln(1-0.423) = ln(0.5)/ln(0.577)).

Further, this model is found to be consistent with the assumption of homoskedasticity and no autocorrelation of the residuals as represented by the 'Autocorrelation LM test' and 'White's Heteroskedasticity test' below:

Null hypothesis: No serial correlation at lag h

Lag	LRE* stat	df	Prob.	Rao F-stat	df	Prob.
1	54.13574	49	0.2848	1.120892	(49, 151.7)	0.2966
2	71.34819	49	0.0202	1.556229	(49, 151.7)	0.0225

Null hypothesis: No serial correlation at lags 1 to h

Lag	LRE* stat	df	Prob.	Rao F-stat	df	Prob.
1	54.13574	49	0.2848	1.120892	(49, 151.7)	0.2966
2	128.0121	98	0.0225	1.391685	(98, 148.1)	0.0344

*Edgeworth expansion corrected likelihood ratio statistic.

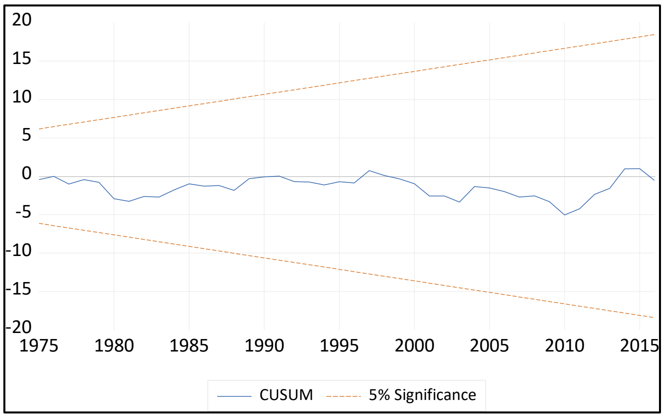
Component	Jarque-Bera	df	Prob.
1	0.364466	2	0.8334
2	1.386222	2	0.5000
3	0.033308	2	0.9835
4	0.078022	2	0.9617
5	0.949550	2	0.6220
6	10.38825	2	0.0055
7	13.18231	2	0.0014
Joint	26.38213	14	0.0231

Joint test:

Chi-sq	df	Prob.
179.7228	140	0.0132

Source: Computed by author using E-views 11

The null hypothesis of no autocorrelation is accepted for lag 1 at 5% significance level and at lag 2 at 1% level of significance. The null hypothesis of homoskedasticity is also accepted at 1% significance level using White's test with cross terms. Further, the Jarque-Bera test for normality accepts the null hypothesis of joint normal distribution of errors at 1% significance level. To ensure stability of the model, we undertake the CUSUM test on the estimated equation generated through the system equation.



Source: Computed by author using E-views 11

As the residuals do not diverge from the zero mean value line and stay within the 5% critical lines, we can establish that the model is significantly stable.

Model 2 –

Now we consider the situation wherein institutional credit to agricultural sector has been calculated through Wholesale Price Index – Food Articles. As food articles doesn't consist of non-agricultural goods like minerals, crude and petroleum gas, it may provide a more accurate image of the credit given the sector. However, as this index does not include non-food articles like fibres (jute, cotton etc), oil seeds (castor, sunflower etc) and rubber, tobacco etc, the value of credit may be underestimated in real terms as these non-food articles are included in other statistical calculations of agricultural sector. However, as the major constituent in changes in value of price index is categorized by food articles, therefore, the weightage of inputs other than food articles in calculation of WPI(FA) can be overlooked (Manual on Wholesale Price Index). Hence, the linear model that has been developed is:

$$\mathrm{GVA} = \beta_0 + \beta_1\mathrm{GIA} + \beta_2\mathrm{Fertiliser\_cons} + \beta_3\mathrm{GFCF\_Pri} + \beta_4\mathrm{GFCF\_Pub} + \beta_5\mathrm{Institutional\_Credit\_FA} + u_t$$

The Augmented Dickey-Fuller (ADF) and Phillips-Perron test for non-stationarity to check whether variables revert back to their means or not bring out the following results-

Variables	**ADF**		**PP Test**	
	Level	First Difference	Level	First Difference
GVA	-1.488530 (0.8186)	-10.51043** (0.00)	-2.119626 (0.5212)	-18.65479** (0.00)
GFCF Pub	-1.266175 (0.8836)	-6.037262** (0.00)	-1.514764 (0.8097)	-6.090459** (0.00)
GFCF Pri	-2.699902 (0.2419)	-4.118331** (0.0131)	-2.131181 (0.5150)	-6.850827** (0.00)
GIA	-4.072230 (0.0136)	-5.039909* (0.0010)	-3.823067 (0.0243)	-8.528190* (0.00)
Fertiliser Cons	-3.978898 (0.0167)	-4.601280* (0.0039)	-2.972899 (0.1509)	-4.446544** (0.0049)
Institutional Credit FA	-3.531256 (0.0502)	-2.171774 (0.4898)	0.936311 (0.9998)	-6.529902** (0.00)

Note: * and ** indicate significance at 1% and 5% level respectively. The parentheses show the p-values. Trend and constant included.

Source: Computed by author using E-views 11

The unit roots test shows that all the variables included in the model are stationary at first difference, i.e., of I(1) order of integration either at 1% or 5% level of significance. The ADF test rejects the null hypothesis that the variable under consideration has a unit root at first difference for all except institutional credit, however, the PP test rejects the same at 5% significance level. This is because the Phillips-Perron test accounts for any disturbance in the error term, so it would have corrected any disturbance that would have been crept in while transforming the nominal values of institutional credit to real terms using WPI (Food Articles).

Next, we derive the optimal lag length for the VAR model for a sample size of 45 observations and a lag order criterion of 3. The results hence obtained suggest one lag based on the SC criteria as it imposes a harsher penalty than AIC and therefore might develop a relatively more accurate model.

Lag	AIC	SC
0	74.36306	74.60881
1	64.65452	66.37477*
2	64.79496	67.98969
3	63.98456*	68.65379

* indicates lag order selected by the criterion

Source: Computed by author using E-views 11

The Johansen Cointegration Test for the null hypothesis that there are no cointegrating relationships against the hypothesis that there exists a cointegrating relationship at a lag interval 0 (as VAR loses a lag by differencing to obtain VECM) produces following results:

Unrestricted Cointegration Rank Test (Maximum Eigenvalue)

Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	0.05 Critical Value	Prob.**
None *	0.603542	41.63339	40.07757	0.0331
At most 1	0.498269	31.03615	33.87687	0.1052
At most 2	0.426046	24.98424	27.58434	0.1038
At most 3	0.273541	14.38079	21.13162	0.3346
At most 4	0.109847	5.236303	14.26460	0.7118
At most 5	0.032415	1.482860	3.841465	0.2233

Max-eigenvalue test indicates 1 cointegrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Source: Authors' calculation using EViews 11

Therefore, there exists a long-run relationship between the variables. The trace statistic is significant at 5% for no cointegrating equation. Hence, we can reject the null hypothesis of no cointegration among the variables against the alternative of at most one cointegration. Moreover, at r=1 as the p-value (0.1052) is greater than 0.05, the null hypothesis of at most 1 cointegrating equations is not rejected. This implies that in order to determine a long run relationship between the variables, there exists one cointegrating equations.

The results obtained from the VECM consequently developed (Appendix 4) with a lag interval of 0 and one cointegrating relationship among the variables are hereby outlined:

For gross value added as the dependent variable the system equation can be represented as:

$$
\begin{aligned}
\mathrm{D(GVA)} = {} & \mathrm{C(1)} * (\mathrm{GVA}(-1) - 6269.691 * \mathrm{GIA}(-1) - 2985.958 \\
& * \mathrm{FERTILISER\_CONS}(-1) - 357.641 * \mathrm{GFCF\_PRI}(-1) - 70.438 \\
& * \mathrm{GFCF\_PUB}(-1) - 33.096 * \mathrm{INSTITUTIONAL\_CREDIT\_FA}(-1) \\
& + 39863.234) + \mathrm{C(2)}
\end{aligned}
$$

The VECM estimates for short-run analysis with GVA as the target variable are:

$$D(GVA) = -0.244ect_{t-1} + 21793.88$$

And the cointegrating equation (i.e., the long-run model) with GVA as the dependent variable is:

$$\begin{aligned} ect_{t-1} = {} & GVA(-1) - 6269.691 * GIA(-1) - 2985.958 * FERTILISER\_CONS(-1) \\ & - 357.641 * GFCF\_PRI(-1) - 70.438 * GFCF\_PUB(-1) - 33.096 \\ & * INSTITUTIONAL\_CREDIT\_FA(-1) + 39863.234 \end{aligned}$$

The long-run coefficient of private investment, gross irrigated area and fertiliser consumption are statistically significant at 95% confidence level; however, all the coefficients are consistent with our economic a prior expectation. Hence, we can interpret Rs1 crore per million hectares of total cropped area rise in private investment as about Rs357.64 crore increase in agricultural output on average, keeping other factors constant. Similarly, a Rs1 crore per million hectares of total cropped area rise in public investment seems to cause on average about Rs70.44 crore rise in the gross value added, keeping other factors constant. Also, Rs1 crore per million hectares of total cropped area increase in institutional credit can be associated with an addition of about Rs33.1 crore in gross value added by the agricultural sector on average, ceteris paribus. Finally, a million hectare rise in gross irrigated area has been found to lead to an increase in gross value added by Rs6269 crore on average.

	Coefficient	Std. Error	t-Statistic	Prob.
C(1)	-0.244065	0.079790	-3.058838	0.0038
C(2)	21793.88	5740.752	3.796346	0.0005

Source: Computed by author using E-views 11

The error correction term can be interpreted through the expressed regression equation developed through the system equation. The coefficient of the error correction term (ECT) of GVA variable (shown by C(1)) is negative and statistically significant at 5% and also lies in the desirable range of -1 to 0. This implies that the model is stable and converges to the steady state. Moreover, values tending to -1 signify a faster speed of adjustment of the system from its previous period disequilibrium towards the long run equilibrium. Therefore, an ECT of -0.244 means that in the short run GVA are adjusted by 24% of the previous year's deviation from the long run equilibrium and 76% remains. In other words, the error correction term of GVA implies that about 24% disturbance in the short-run is corrected each year. This implies that the existing disequilibrium will be reduced to half in about 2.5 years (that is, ln(0.5)/ln(1-0.244) = ln(0.5)/ln(0.756)).

Null hypothesis: No serial correlation at lag h						
Lag	LRE* stat	df	Prob.	Rao F-stat	df	Prob.
1	40.01093	36	0.2966	1.128538	(36, 143.3)	0.3032
2	64.96227	36	0.0022	1.989040	(36, 143.3)	0.0024

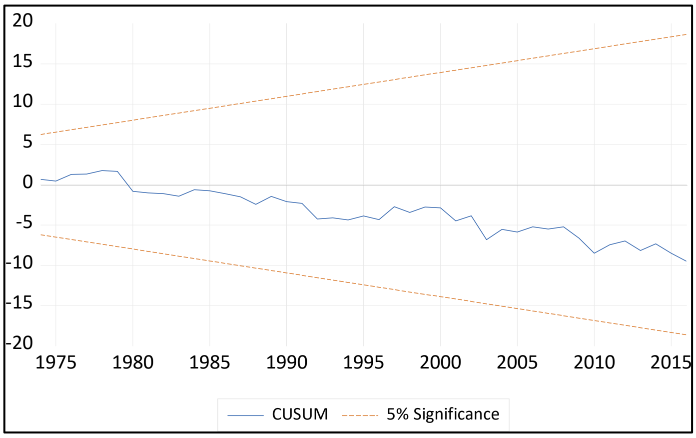
Null hypothesis: No serial correlation at lags 1 to h						
Lag	LRE* stat	df	Prob.	Rao F-stat	df	Prob.
1	40.01093	36	0.2966	1.128538	(36, 143.3)	0.3032
2	105.9084	72	0.0057	1.611629	(72, 147.3)	0.0078

Component	Jarque-Bera	df	Prob.
1	1.291786	2	0.5242
2	0.169258	2	0.9189
3	1.394933	2	0.4978
4	1.648929	2	0.4385
5	0.527496	2	0.7682
6	2.911446	2	0.2332
Joint	7.943848	12	0.7895

Joint test:		
Chi-sq	df	Prob.
68.75442	42	0.0057

Source: Computed by author using E-views 11

The model is found to be weakly consistent with the assumption of homoskedasticity and no autocorrelation of the residuals as represented by the 'Autocorrelation LM test' and 'White's Heteroskedasticity test'. While, the null hypothesis of no autocorrelation is accepted for lag 1 at 5% significance level, however, null hypothesis of homoskedasticity is rejected at 1% significance level using White's test with cross terms. This implies that our result is no longer efficient. Further, the Jarque-Bera test for normality accepts the null hypothesis of joint normal distribution of errors at 5% significance level. At last, to ensure stability of the model, we undertake the CUSUM test on the estimated equation generated through the system equation.



Source: Computed by author using E-views 11

Though the residuals trend downward from the zero mean value line, however, they stay within the 5% critical lines. Therefore, we can establish that the model is significantly stable over time.

Before enumerating the results of model 3 and model 4, it is worthwhile to again note that the following models consider values for the dependent variable 'GVA' and the explanatory variables 'GFCF_Pri' and 'GFCF_Pub' as that provided by the entire agriculture and allied sector and not only by the agriculture sector as was the case in the previous models. Moreover, the data set for the independent variable 'Institutional_Credit' has been transformed into real terms using WPI (Primary Articles) in model 3 and WPI (Food Articles) in model 4 so as to account for the reasons explained in detail at the beginning of model 1 and model 2 before discussing their respective results. The key results of model 3 and model 4 are henceforth presented.

Model 3 –

The linear model that has been developed is:

$$\mathrm{GVA} = \beta_0 + \beta_1 \mathrm{PerCapita\_Foodgrains} + \beta_2 \mathrm{GIA} + \beta_3 \mathrm{Fertiliser\_cons} + \beta_4 \mathrm{GFCF\_Pri} + \beta_5 \mathrm{GFCF\_Pub} + \beta_6 \mathrm{Institutional\_Credit\_PA} + u_t$$

As we work our model on a yearly time-series data, there might be presence of trend in the variables and they may not revert back to their means, i.e., the variables may be non-stationary. This would lead to biased estimators and hence, flawed analysis. This implies that in the short-run, the value added by agricultural sector might deviate from its steady state. Therefore, in order to maintain statistical validity of the data and generate long-term estimates, we test the variables for non-stationarity which brings out the following results-

Variables	**ADF**		**PP Test**	
	Level	First Difference	Level	First Difference
GVA	-1.279017 (0.8802)	-10.51353** (0.00)	-2.035066 (0.5667)	-22.31900** (0.00)
GFCF Pub	-1.328062 (0.8679)	-6.184107** (0.00)	-1.552820 (0.7957)	-6.229256** (0.00)
GFCF Pri	0.204521 (0.9972)	-4.259760** (0.0092)	-2.047062 (0.5603)	-6.876001** (0.00)
GIA	-4.072230 (0.0136)	-5.039909* (0.0010)	-3.823067 (0.0243)	-8.528190* (0.00)
Fertiliser Cons	-3.978898 (0.0167)	-4.601280* (0.0039)	-2.972899 (0.1509)	-4.446544** (0.0049)
Institutional Credit PA	-1.194513 (0.8970)	-1.702535 (0.7288)	2.234386 (1.00)	-6.533358** (0.00)
PerCapita Foodgrains	-2.832595 (0.1939)	-5.488529** (0.0003)	-5.773997* (0.0001)	-17.04319* (0.00)

Note: * and ** indicate significance at 1% and 5% level respectively. The parentheses show the p-values. Trend and constant included.

Source: Computed by author using E-views 11

The unit roots test shows that all the variables included in the model are stationary at first difference, i.e., of I(1) order of integration either at 1% or 5% level of significance. The ADF test rejects the null hypothesis that the variable under consideration has a unit root at first difference for all except institutional credit, however, the PP test rejects the same at 5% significance level. This is because the Phillips-Perron test accounts for any disturbance in the error term, so it would have corrected any disturbance that would have been crept in while transforming the nominal values of institutional credit to real terms using WPI (Primary Articles).

The optimal lag length using the SC criterion (as it selects a more parsimonious model than AIC criterion) for a VAR model given a sample size of 45 observations is one. Therefore, we use one lag as the optimal number of lags in the model.

Lag	AIC	SC
0	81.99701	82.28371
1	71.74552	74.03917*
2	70.82290	75.12350
3	69.43299*	75.74055

* indicates lag order selected by the criterion

Source: Computed by author using E-views 11

As a VECM model has a lag length of one less than the optimal lag of VAR model. Hence, our VECM would be of lag order 0, i.e., there are no lags of the first differenced endogenous variables and only one lag in the level series.

Next, we proceed to determine the presence of cointegration using Johansen Cointegration Test. If the cointegrating relationship exists then we can say that there exists a long-run equilibrium among the variables and proceed forward with the VECM(0) model. However, if we find no presence of a cointegrating equation, then we perform a standard VAR model in differenced terms at lag order 0. The results are illustrated below:

Unrestricted Cointegration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None *	0.714035	156.4771	125.6154	0.0002
At most 1 *	0.550333	100.1423	95.75366	0.0241
At most 2	0.421735	64.17612	69.81889	0.1298
At most 3	0.326379	39.52857	47.85613	0.2398
At most 4	0.272943	21.74961	29.79707	0.3126
At most 5	0.119037	7.405847	15.49471	0.5309
At most 6	0.037128	1.702572	3.841465	0.1920

Trace test indicates 2 cointegrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Source: Authors' calculation using EViews 11

The Johansen cointegration test suggests that there exists a long-run relationship between the variables. Firstly, the trace statistic is significant at 5% for no cointegrating equation. Therefore, we can reject the null hypothesis of no cointegration among the variables against the alternative of at most one cointegration. Also, we can reject the null hypothesis of at most one cointegrating vectors versus the alternative of two cointegrating vectors as the trace statistic (100.14) is greater than the 0.05 critical value (95.75). But, at r=2 as the p-value (0.1298) is greater than 0.05, the null hypothesis of at most 2 cointegrating equations is not rejected. Hence, we can conclude that in order to determine a long run relationship between the variables, there exists two cointegrating equations.

This implies that the VECM model (Appendix 5) hence developed has a lag interval of zero and two cointegrating relationships among the variables. The results obtained from the VECM are represented and interpreted hereby:

The system equation to know the p-values and generate long-run analysis is:

$$
\begin{aligned}
\mathrm{D(GVA)} = {} & \mathrm{C(1)} * (\mathrm{GVA}(-1) - 14221.695 * \mathrm{GIA}(-1) + 2277.13 \\
& * \mathrm{FERTILISER\_CONS}(-1) - 1240.354 * \mathrm{GFCF\_PRI}(-1) + 412.352 \\
& * \mathrm{GFCF\_PUB}(-1) + 61.156 * \mathrm{INSTITUTIONAL\_CREDIT\_PA}(-1) \\
& + 281252.434) + \mathrm{C(2)} * (\mathrm{PERCAPITA\_FOODGRAINS}(-1) + 0.125 \\
& * \mathrm{GIA}(-1) - 0.482 * \mathrm{FERTILISER\_CONS}(-1) + 0.212 * \mathrm{GFCF\_PRI}(-1) \\
& + 0.11 * \mathrm{GFCF\_PUB}(-1) - 0.0381 * \mathrm{INSTITUTIONAL\_CREDIT\_PA}(-1) \\
& - 214.724) + \mathrm{C(3)}
\end{aligned}
$$

The VECM estimates for short-run analysis with GVA as the target variable are:

$$\mathrm{D(GVA)} = -0.388\mathrm{ect}_{t-1}^{1} - 2490.189\mathrm{ect}_{t-1}^{2} + 23792.98$$

And the cointegrating equation (i.e., the long-run model) with GVA as the dependent variable is:

$$
\begin{aligned}
\mathrm{ect}_{t-1} = {} & 1.000\mathrm{GVA}(-1) - 14221.695 * \mathrm{GIA}(-1) + 2277.13 \\
& * \mathrm{FERTILISER\_CONS}(-1) - 1240.354 * \mathrm{GFCF\_PRI}(-1) + 412.352 \\
& * \mathrm{GFCF\_PUB}(-1) + 61.156 * \mathrm{INSTITUTIONAL\_CREDIT\_PA}(-1) \\
& + 281252.434
\end{aligned}
$$

From the long-run model, following relationship among the explanatory and dependent variable can be deduced. Only the long-run coefficient of GIA and private investment is significant at 95% confidence level. We can interpret Rs 1 crore per million hectares of total cropped area rise in private investment as about Rs 1240.35 crore increase in agricultural output on average, keeping other factors constant. Similarly, a Rs 1 crore per million hectares of total cropped area rise in public investment seems to cause on average about Rs 412.35 crore fall in the gross value added, keeping other factors constant. Interestingly, Rs1 crore/million hectare of total cropped area increase in institutional credit can be associated with about Rs 61.16 crore decline in gross value added by the agricultural sector on average, ceteris.

Next to interpret the coefficient of error correction term, we estimate an OLS equation using the system equation developed before by applying least square method. The results of the estimated equation with D(GVA) as the dependent variable are:

	Coefficient	Std. Error	t-Statistic	Prob.
C(1)	-0.388814	0.066204	-5.872955	0.0000
C(2)	-2490.189	436.0966	-5.710177	0.0000
C(3)	23792.98	4765.276	4.992991	0.0000

Source: Computed by author using E-views 11

The coefficient of the error correction term (ECT) of GVA variable (shown by C(1)) is negative and statistically significant at 5% and also lies in the desirable range of -1 to 0. This implies that the model is stable and converges to the steady state. Moreover, the values tending to -1 signify a faster speed of adjustment of the system from its previous period disequilibrium towards the long run equilibrium. Therefore, an ECT of -0.388 means that in the short run GVA are adjusted by 38% of the previous year's deviation from the long run equilibrium and 62%. In other words, the error correction term of GVA implies that about 42% disturbance in the short-run is corrected each year. This implies that the existing disequilibrium will be reduced to half in about 1.4 years (that is, ln(0.5)/ln(1-0.388) = ln(0.5)/ln(0.612)).

Further, this model is found to be consistent with the assumption of homoskedasticity, normal distribution of errors and no autocorrelation of the residuals as represented by the 'Autocorrelation LM test', 'Jarque-Bera test' and 'White's Heteroskedasticity test' below:

Null hypothesis: No serial correlation at lag h

Lag	LRE* stat	df	Prob.	Rao F-stat	df	Prob.
1	51.89042	49	0.3619	1.067193	(49, 151.7)	0.3744
2	69.21473	49	0.0301	1.499919	(49, 151.7)	0.0331

Null hypothesis: No serial correlation at lags 1 to h

Lag	LRE* stat	df	Prob.	Rao F-stat	df	Prob.
1	51.89042	49	0.3619	1.067193	(49, 151.7)	0.3744
2	122.4242	98	0.0480	1.310129	(98, 148.1)	0.0684

Component	Jarque-Bera	df	Prob.
1	0.510724	2	0.7746
2	1.384386	2	0.5005
3	0.174794	2	0.9163
4	0.148918	2	0.9282
5	0.447879	2	0.7994
6	12.88651	2	0.0016
7	9.550463	2	0.0084
Joint	25.10367	14	0.0336

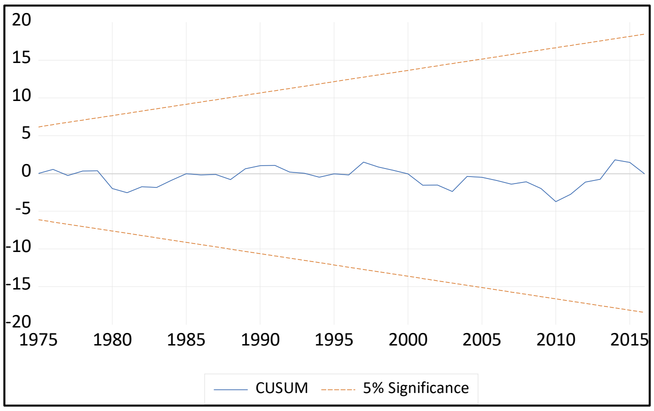
Joint test:

Chi-sq	df	Prob.
173.2028	140	0.0297

Source: Computed by author using E-views 11

The null hypothesis of no autocorrelation is accepted for lag 1 at 5% significance level and at lag 2 at 1% level of significance. The null hypothesis of homoskedasticity is also accepted at 1% significance level using White's test with cross terms. Further, the Jarque-Bera test for normality accepts the null hypothesis of joint normal distribution of errors at 1% significance level.

To ensure stability of the model, we undertake the CUSUM test on the estimated equation generated through the system equation.



Source: Computed by author using E-views 11

As the residuals do not diverge from the zero mean value line and stay within the 5% critical lines, we can establish that the model is significantly stable.

Model 4 –

The linear model with the dependent variable as Gross Value Added is:

$$\mathrm{GVA} = \beta_0 + \beta_1\mathrm{GIA} + \beta_2\mathrm{Fertiliser\_cons} + \beta_3\mathrm{GFCF\_Pri} + \beta_4\mathrm{GFCF\_Pub} + \beta_5\mathrm{Institutional\_Credit\_FA} + u_t$$

The Augmented Dickey-Fuller (ADF) and Phillips-Perron test to examine for stationarity of the variables brings out the following results-

Variables	ADF		PP Test	
	Level	First Difference	Level	First Difference
GVA	-1.279017 (0.8802)	-10.51353** (0.00)	-2.035066 (0.5667)	-22.31900** (0.00)
GFCF Pub	-1.328062 (0.8679)	-6.184107** (0.00)	-1.552820 (0.7957)	-6.229256** (0.00)
GFCF Pri	0.204521 (0.9972)	-4.259760** (0.0092)	-2.047062 (0.5603)	-6.876001** (0.00)
GIA	-4.072230 (0.0136)	-5.039909* (0.0010)	-3.823067 (0.0243)	-8.528190* (0.00)
Fertiliser Cons	-3.978898 (0.0167)	-4.601280* (0.0039)	-2.972899 (0.1509)	-4.446544** (0.0049)
Institutional Credit FA	-3.531256 (0.0502)	-2.171774 (0.4898)	0.936311 (0.9998)	-6.529902** (0.00)

Note: * and ** indicate significance at 1% and 5% level respectively. The parentheses show the p-values. Trend and constant included.

Source: Computed by author using E-views 11

The unit roots test shows that all the variables included in the model are stationary at first difference, i.e., of I(1) order of integration either at 1% or 5% level of significance. The ADF test rejects the null hypothesis that the variable under consideration has a unit root at first difference for all except institutional credit, however, the PP test rejects the same at 5% significance level. This is because the Phillips-Perron test accounts for any disturbance in the error term, so it would have corrected any disturbance that would have been crept in while transforming the nominal values of institutional credit to real terms using WPI (Food Articles).

Next, we determine the optimal lag length for a sample of 45 observations:

Lag	AIC	SC
0	74.68455	74.93030
1	64.96099	66.68123*
2	65.05514	68.24988
3	64.09395*	68.76318

* indicates lag order selected by the criterion

Source: Computed by author using E-views 11

The information criterion SC suggest one lag for the optimal number of lags in the model while, AIC suggests three as optimal lag. Since, SC imposes a harsher penalty than AIC for adding new variables, i.e., it selects a more parsimonious model, hence, the lag selected by SC and consequently the model developed can be relatively more accurate than that of AIC. Therefore, we select 1 lag order for the VAR model.

By differencing the VAR model and consequently losing a lag, it can be rewritten as VECM model. Hence, the VECM derived would have a lag order of 0, i.e., there are no lags of the first differenced endogenous variables and only one lag in the level series. To derive VECM, we first determine the presence of cointegrating relationship among the variables using Johansen Cointegration Test at lag order of 0.

Unrestricted Cointegration Rank Test (Maximum Eigenvalue)

Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	0.05 Critical Value	Prob.**
None *	0.598929	41.11278	40.07757	0.0381
At most 1	0.449212	26.83826	33.87687	0.2721
At most 2	0.387893	22.08820	27.58434	0.2159
At most 3	0.268039	14.04127	21.13162	0.3617
At most 4	0.117267	5.612948	14.26460	0.6632
At most 5	0.033060	1.512862	3.841465	0.2187

Max-eigenvalue test indicates 1 cointegrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Source: Authors' calculation using EViews 11

The test confirms existence of a long-run relationship between the variables. The trace statistic is significant at 5% for no cointegrating equation. Therefore, we can reject the null hypothesis of no cointegration among the variables against the alternative of at most one cointegration. However, at r=1 as the p-value (0.2721) is greater than 0.05, the null hypothesis of at most 1 cointegrating equations is not rejected. Hence, we can conclude that there exists one cointegrating equation.

The VECM model (Appendix 6) therefore developed has a lag interval zero and one cointegrating relationship among the variables. The key characteristics of the model are:

The system equation with gross value added as the dependent variable:

$$\begin{aligned}\mathrm{D(GVA)} = {} & \mathrm{C(1)} * (\mathrm{GVA}(-1) + 1333.291 * \mathrm{GIA}(-1) - 7561.908 \\ & * \mathrm{FERTILISER\_CONS}(-1) - 790.21 * \mathrm{GFCF\_PRI}(-1) - 319.423 \\ & * \mathrm{GFCF\_PUB}(-1) + 59.722 * \mathrm{INSTITUTIONAL\_CREDIT\_FA}(-1) \\ & - 153605.233) + \mathrm{C(2)}\end{aligned}$$

The VECM estimates for short-run analysis with GVA as the target variable are:

$$\mathrm{D(GVA)} = -0.0823 ect_{t-1} + 23792.98$$

And the cointegrating equation (i.e., the long-run model) with GVA as the dependent variable is:

$$\begin{aligned}\mathrm{ect}_{t-1} = {} & 1.000\mathrm{GVA}(-1) + 1333.291 * \mathrm{GIA}(-1) - 7561.908 * \mathrm{FERTILISER\_CONS}(-1) \\ & - 790.21 * \mathrm{GFCF\_PRI}(-1) - 319.423 * \mathrm{GFCF\_PUB}(-1) + 59.722 \\ & * \mathrm{INSTITUTIONAL\_CREDIT\_FA}(-1) - 153605.233) + \mathrm{C(2)}\end{aligned}$$

The long-run coefficients of private investment and fertiliser consumption are statistically significant at 95% confidence level. We can interpret Rs 1 crore per million hectares of total cropped area rise in private investment as about Rs 790.21 crore increase in agricultural output on average, keeping other factors constant. Similarly, a Rs 1 crore per million hectares of total cropped area rise in public investment seems to cause on average about Rs 319.42 crore rise in the gross value added, keeping other factors constant. Interestingly, Rs 1 crore/million hectare of total cropped area increase in institutional credit can be associated with about Rs 59.72 crore decline in gross value added by the agricultural sector on average, ceteris paribus. Also, for a million hectare increase in gross irrigated area, gross value-added on average falls by RS 1333 crore, ceteris paribus.

The coefficient of the error correction term for the equation with D(GVA) as the dependent variable is hereby interpreted:

	Coefficient	Std. Error	t-Statistic	Prob.
C(1)	-0.082329	0.034339	-2.397558	0.0209
C(2)	23792.98	5997.899	3.966886	0.0003

Source: Computed by author using E-views 11

The coefficient of the error correction term (ECT) of GVA variable (shown by C(1)) is negative and statistically significant at 5% and also lies in the desirable range of (-1 to 0). This implies that the model is stable and converges to the steady state. An ECT of -0.0823 means that in the short run GVA are adjusted by 8.23% of the previous year's deviation from the long run equilibrium and 91.77% remains. This implies that the existing disequilibrium will be reduced to half in about 8 years (that is, ln(0.5)/ln(1-0.0823) = ln(0.5)/ln(0.9177)).

The model however is weakly consistent with the assumption normal distribution of errors, of homoskedasticity and of no autocorrelation of the residuals.

Null hypothesis: No serial correlation at lag h

Lag	LRE* stat	df	Prob.	Rao F-stat	df	Prob.
1	37.71881	36	0.3906	1.056002	(36, 143.3)	0.3975
2	68.33612	36	0.0009	2.116018	(36, 143.3)	0.0010

Null hypothesis: No serial correlation at lags 1 to h

Lag	LRE* stat	df	Prob.	Rao F-stat	df	Prob.
1	37.71881	36	0.3906	1.056002	(36, 143.3)	0.3975
2	108.7392	72	0.0034	1.668871	(72, 147.3)	0.0047

Component	Jarque-Bera	df	Prob.
1	1.241388	2	0.5376
2	0.548394	2	0.7602
3	0.490076	2	0.7827
4	1.726297	2	0.4218
5	0.705730	2	0.7027
6	2.791046	2	0.2477
Joint	7.502930	12	0.8227

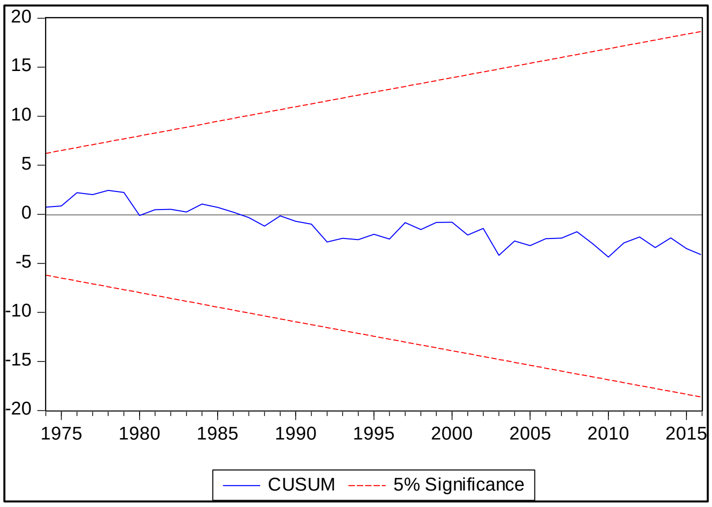
Joint test:

Chi-sq	df	Prob.
71.15612	42	0.0033

Source: Computed by author using E-views 11

The null hypothesis of no autocorrelation is accepted for lag 1 at 5% significance level. The null hypothesis of homoskedasticity is rejected at 1% significance level using White's test with cross terms. This implies that our result is no longer efficient. Further, the Jarque-Bera test for normality accepts the null hypothesis of joint normal distribution of errors at 5% significance level.

To ensure stability of the model, we undertake the CUSUM test on the estimated equation generated through the system equation.



Source: Computed by author using E-views 11

As the residuals do not diverge form the zero mean value line and stay within the 5% critical lines, we can establish that the model is significantly stable over time.

Conclusion and Policy Implication

Based on the interpretation of the models, it can be established that model 2 stands closest to the findings as suggested by literature. Also, most of the long-run estimates generated by the model are significant at 95% confidence level when compared to the other models. Therefore, the positive and statistically significant relation of irrigated area and fertiliser consumption with gross value-added stand in tandem with findings of Chand and Pandey,2008. While, a positive and significant relation between private investment and gross value added by the agricultural sector is established. Further, the model denotes a statistically insignificant yet positive impact of public investment as well as institutional credit on agricultural output. This implies that the public investment and direct institutional credit don't have a direct impact on agricultural output. Rather, they indirectly lead to a growth in output by complementing other parameters. Public investment, therefore, helps to crowd-in private investment and direct credit helps farmers to access inputs like fertilisers, power, irrigation facility etc, which consequently lead to a positive and significant growth of agricultural output. This analysis of public investment and institutional credit is further strengthened by the fact that it corroborates with our literature analysis.

Though, the results generated are heteroskedastic which implies that although the parameters are unbiased but they are no longer efficient. Therefore, the estimates are not BLUE. However, it is important to consider the fact that this time series analysis has been conducted on a finite sample of 45 observations. The data set though can provide an idea of the trends and impact of the parameters on the dependent variable, but it isn't large enough to provide efficient estimates through VECM. Further, the efficiency of the model might also be affected by data quality issues like discrepancies that might have crept in while debasing WPI values to a common base year so as to derive institutional credit in real terms. Also, as all the parameters have not been expressed in common units like gross irrigated area has been expressed in million hectares while private investment in rupee crores per million hectares. Similarly, better results might have been obtained by transforming this linear regression model. Therefore, these issues can be accounted for in any future research.

The aim of the paper was to analyse the various factors that affect agricultural output. While, the primary objective of the study to find whether fall in public investment is justified was refuted with credible literature, the use of VECM model further reinforced our claim. In the course of study, several other variables were found to have a direct impact on gross value added by the agricultural sector, like gross irrigated area and fertiliser consumption. The paper used a yearly data set from 1970-2016 to develop VECM model. Based on the data available, four linear models were developed and the variables were checked for stationarity. The models were distinct in respect of the values reported for GVA, private investment and public investment. While, model 1 and model 2 reported aggregated values for only crop and livestock sector, the other two models accounted for the entre agriculture and allied activities. Two different WPI series (namely, WPI-Food Articles and WPI-Primary Articles) were used to debase institutional credit to real terms with base year 2011-12. VECM models were developed and the individual results interpreted to select the best model. The results validated our use of the agriculture (that is, crop and livestock) sector as a proxy for the agriculture and allied sector as statistically significant long-run estimates in line with our literature analysis were obtained in case of model 2. Further, WPI-FA series was found to be a better means to debase institutional credit as indicated by its long-run estimate obtained in model 2. The estimate is in tandem with our a priori expectation and hence, justifies that the non-agricultural articles included in WPI-PA series are insignificant in respect of analysis of agricultural sector and therefore, WPI-FA provides more accurate image of the institutional credit directed towards agricultural sector.

Based on our analysis therefore, the policy suggestions that can be deduced are:

- As we have seen that public investment has stagnated over the years even after the presence of extensive research that it often helps to crowd-in private investment, efforts should be made to revive the same. This is a source of concern for the rural economy as it majorly revolves around the agricultural sector.
- One of the reasons for fall in public investment can be because of rising subsidies that are provided in the agricultural sector on electricity and fertilizers. Such current expenditure is also questionable on the parameter of sustainability. Unchecked spurt in subsidy has led to an inefficient growth of agricultural output marked by excessive use of resources like water, fertilizers etc causing deleterious environmental consequences. Therefore, efforts should be made to reduce subsidies rationally to an efficient level wherever possible.
- A major source of private investment is from the households. Corporate investment in the agricultural sector in India is still limited and hence, holds immense opportunity to expand. Major areas that require investment in the sector are warehousing, logistics and mechanical inputs. Forward linkages like

agro-industries, manufacturing and service sector in rural areas can also benefit from improvement in corporate investment.

- To enable such spurt in private investment however requires several legal amendments and deregulations like the recently passed Farmers' Produce Trade and Commerce (Promotion and Facilitation) Bill 2020, Essential Commodities (Amendment) Bill 2020 and Farmers (Empowerment and Protection) Agreement on Price Assurance and Farm Services Bill 2020. Also, easy access to finance and ease of business needs to be assured to booming agri-startups.
- The aforementioned policy proposition can also help India to improve its Agricultural Orientation Index and reach closer to ensure Goal 2 of SDG's.
- As seen from the study, irrigation still has a significant impact on output levels, especially in dry and arid regions. This calls for calibrated efforts to ensure access of modern irrigation means to farmers in those regions. Also, incentives must be provided to grow crops suitable for the region so as to limit any harm on the environment.
- Finally, income disparity among workers in the agricultural sector across the states imply varying results of current agricultural policy across the country. A shift in focus of the policy makers from already agri-rich states/regions to marginal areas can have dual benefits in form of reduced burden on incumbent leaders to produce high yield on already strained fields and an improvement in income and output levels among the lagging states/regions. Also, alternative crops and agribusinesses like floriculture, bee keeping etc must also be given focus as they hold potential to diversify income stream of the farmers and consequently reduce their exposure to risk like crop failure, income uncertainty etc.

Way Ahead

This paper acts as a beginning step to several research avenues that aim to deliver results on long-term trends in the agricultural sector. The paper works on a small data set to establish efficient results, however, overtime as the statistical publications get more detailed, generating effective results would be possible. Due to the publication of highly disaggregated and overlapped datasets on subsidies provided to the agriculture and allied sector, it was not included as a variable in the study despite presence of credible literature that such expenditures have a negative impact on agricultural output. Moreover, the agricultural output is also impacted by the overall performance of the rural economy. Factors like literacy rate, population, communication, logistics, infrastructure, banking services etc, that act as a good proxy for rural economy are also not included in the study. Further research can also take these factors into consideration while generating results.

While similar research has been conducted at state level, at national level such publications are limited if not absent. This is mainly because of lack of credible data for several variables at the national level that have been reported for long enough periods to pursue time series analysis and generate significant results. Efforts can be made to develop a detailed dataset at national level that can be used to carry research.

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Appendix:

1) Deflating nominal values of Institutional Credit to real terms using WPI(PA)

A. Linking of WPI series with different base years to develop a new WPI(PA) series with base year 2011-12-

Step 1 –
As per the Handbook of Statistics on Indian Economy published by RBI, the WPI series is available for base years 1970-71, 1981-82, 1993-94, 2004-05 and 2011-12 respectively. To link these separate WPI series, the arithmetic conversion method has been used as suggested by the Government of India.

Step 2 –
As we have several WPI with different base years, therefore each WPI has at least one common year. For eg - in WPI list of base year 1970-71 and base 1981-82, the year 1981-82 is common. Using this concept which can be extended to all base years, we first link the WPI series with base year 1970-71 to 1981-82 series to derive a new WPI series with base year of 1981-82.

Step 3 –
This newly formed WPI series with base year at 1981-82 is then linked to the series with base year at 1993-94 to obtain a new WPI series with base at 1993-94. This process is carried over again to achieve a WPI series of base year 2004-05.

Step 5 –
It has to be noted that this WPI series at base 2004-05 has linked all the previous WPI series and the corresponding WPI values from 1970-71 to 2011-12 are expressed using 2004-05 as the base year. Finally, this series is linked to the latest WPI series of base year 2011-12 so as to deflate all the values of the WPI series going back to 1970-71 to base 2011-12.

B. Having debased the WPI series of different base years to establish a new WPI series with a common base year of 2011-12, we can now use this calculated series to deflate the nominal values of ‘Institutional Credit to the Agricultural and Allied Sector’ to real values with base year of 2011-12. First, we convert the WPI into its decimal equivalent as shown in column 4 by dividing by base value 100. Then we divide the nominal credit flow by WPI in decimal form (calculated in previous step) to arrive at real credit flow.

Year	Nominal Credit Flow	WPI_PA	WPI (Decimal form)	Real Credit Flow
1970-71	818	4.001	0.040	20444.91
1971-72	883	4.037	0.040	21872.65
1972-73	1156	4.433	0.044	26076.54
1973-74	1187	5.673	0.057	20922.15
1974-75	1391	7.102	0.071	19586.67
1975-76	1675	6.634	0.066	25250.04
1976-77	2037	6.690	0.067	30449.95
1977-78	2155	7.354	0.074	29304.45
1978-79	2641	7.262	0.073	36368.35
1979-80	2928	8.262	0.083	35439.12
1980-81	3436	9.502	0.095	36159.42
1981-82	4296	10.579	0.106	40610.16
1982-83	4352	11.287	0.113	38556.26
1983-84	5244	12.504	0.125	41938.76
1984-85	6167	13.276	0.133	46451.59
1985-86	7159	13.297	0.133	53837.82
1986-87	7720	14.503	0.145	53229.24
1987-88	9198	16.143	0.161	56978.27
1988-89	9381	16.936	0.169	55389.60
1989-90	10628	17.307	0.173	61409.94
1990-91	10188	19.560	0.196	52086.17
1991-92	11538	23.104	0.231	49939.97
1992-93	12530	24.817	0.248	50488.62
1993-94	15013	26.542	0.265	56563.62
1994-95	18773	30.735	0.307	61079.41
1995-96	23692	33.257	0.333	71239.42
1996-97	26345	36.044	0.360	73091.72
1997-98	28656	36.999	0.370	77450.20
1998-99	32697	41.458	0.415	78867.24
1999-00	45534	41.936	0.419	108579.66
2000-01	48187	43.130	0.431	111723.95
2001-02	54195	44.696	0.447	121251.43
2002-03	65175	46.183	0.462	141124.21
2003-04	83427	48.173	0.482	173180.80
2004-05	105303	49.925	0.499	210921.91
2005-06	144021	52.072	0.521	276581.08
2006-07	189513	57.064	0.571	332103.71
2007-08	194953	61.857	0.619	315166.15
2008-09	245976	68.647	0.686	358319.95
2009-10	384514	77.334	0.773	497212.10
2010-11	468291	91.063	0.911	514247.19
2011-12	511029	100.000	1.000	511029.00

2012-13	607375	111.400	1.114	545219.93
2013-14	730122	122.400	1.224	596504.90
2014-15	845328	125.100	1.251	675721.82
2015-16	915509	124.600	1.246	734758.43
2016-17	1065755	128.900	1.289	826807.60
2017-18	1168503	130.600	1.306	894718.99
2018-19	1256830	134.200	1.342	936535.02

2) Deflating nominal values of Institutional Credit to real terms using WPI(FA)

A. We follow the same steps as specified in Appendix 1 to link WPI series with different base years and develop a new WPI(FA) series with base year 2011-12.

B. Following the same steps as specified in Appendix 1, the new institutional credit series in real terms is derived.

Year	Nominal Credit Flow	WPI_FA	WPI (Decimal form)	Real Credit Flow
1970-71	818	4.166	0.042	19634.96
1971-72	883	4.212	0.042	20964.59
1972-73	1156	4.637	0.046	24930.99
1973-74	1187	5.691	0.057	20858.20
1974-75	1391	7.170	0.072	19400.95
1975-76	1675	6.820	0.068	24560.82
1976-77	2037	6.470	0.065	31484.47
1977-78	2155	7.232	0.072	29797.12
1978-79	2641	7.186	0.072	36749.89
1979-80	2928	7.774	0.078	37664.85
1980-81	3436	8.665	0.087	39652.14
1981-82	4296	9.794	0.098	43862.00
1982-83	4352	10.882	0.109	39994.38
1983-84	5244	12.390	0.124	42324.94
1984-85	6167	12.909	0.129	47773.02
1985-86	7159	13.134	0.131	54506.43
1986-87	7720	14.476	0.145	53329.44
1987-88	9198	15.779	0.158	58293.75
1988-89	9381	17.346	0.173	54082.25
1989-90	10628	17.561	0.176	60519.51
1990-91	10188	19.647	0.196	51853.99
1991-92	11538	23.624	0.236	48840.20
1992-93	12530	26.543	0.265	47206.95
1993-94	15013	27.855	0.279	53896.69
1994-95	18773	31.421	0.314	59747.42
1995-96	23692	34.039	0.340	69602.54
1996-97	26345	38.245	0.382	68884.61
1997-98	28656	39.387	0.394	72754.65
1998-99	32697	44.401	0.444	73640.06
1999-00	45534	46.100	0.461	98771.66
2000-01	48187	47.493	0.475	101461.22
2001-02	54195	49.053	0.491	110482.74
2002-03	65175	49.916	0.499	130568.26
2003-04	83427	50.557	0.506	165015.43
2004-05	105303	51.894	0.519	202918.88
2005-06	144021	54.696	0.547	263309.74
2006-07	189513	59.938	0.599	316183.16
2007-08	194953	64.141	0.641	303943.71
2008-09	245976	69.953	0.700	351628.90
2009-10	384514	80.643	0.806	476807.26
2010-11	468291	93.202	0.932	502448.08
2011-12	511029	100.000	1.000	511029.00
2012-13	607375	110.900	1.109	547678.09
2013-14	730122	124.500	1.245	586443.37
2014-15	845328	131.500	1.315	642834.98
2015-16	915509	134.900	1.349	678657.52
2016-17	1065755	140.300	1.403	759625.80
2017-18	1168503	143.200	1.432	815993.72
2018-19	1256830	143.700	1.437	874620.74

3) VECM Model 1

Sample (adjusted): 1972 2016
Included observations: 45 after adjustments
Standard errors in ( ) & t-statistics in [ ]

Cointegrating Eq:	CointEq1	CointEq2
GVA(-1)	1.000000	0.000000
PERCAPITA FOODG...	0.000000	1.000000
GIA(-1)	-14087.36	0.578914
	(12010.7)	(2.26963)
	[-1.17290]	[0.25507]
FERTILISER CONS(-1)	3066.021	-0.885245
	(6354.74)	(1.20084)
	[0.48248]	[-0.73719]
GFCF PRI(-1)	-2077.642	0.418370
	(647.220)	(0.12230)
	[-3.21010]	[3.42076]
GFCF PUB(-1)	-196.9204	0.173452
	(1789.40)	(0.33814)
	[-0.11005]	[0.51296]
INSTITUTIONAL CRE...	182.9456	-0.063725
	(203.074)	(0.03837)
	[0.90088]	[-1.66061]
C	669942.9	-281.9698

Error Correction:	D(GVA)	D(PERCAP...	D(GIA)	D(FERTILI...	D(GFCF PRI)	D(GFCF P...	D(INSTITUT...
CointEq1	-0.422569	-0.000103	-7.18E-06	-8.39E-06	-0.000354	-1.75E-05	-0.000228
	(0.06817)	(2.1E-05)	(4.3E-06)	(1.1E-05)	(0.00016)	(3.4E-05)	(0.00029)
	[-6.19842]	[-5.03663]	[-1.67916]	[-0.79823]	[-2.19224]	[-0.50635]	[-0.79157]
CointEq2	-2265.041	-0.572370	-0.043620	-0.058459	-2.165695	-0.067047	0.352912
	(372.236)	(0.11200)	(0.02336)	(0.05741)	(0.88184)	(0.18837)	(1.57492)
	[-6.08495]	[-5.11064]	[-1.86763]	[-1.01833]	[-2.45588]	[-0.35594]	[0.22408]
C	21793.88	0.146667	1.298222	2.714541	15.74317	3.012317	80.12164
	(4631.00)	(1.39334)	(0.29057)	(0.71420)	(10.9710)	(2.34347)	(19.5936)
	[4.70609]	[0.10526]	[4.46786]	[3.80081]	[1.43498]	[1.28541]	[4.08917]
R-squared	0.477977	0.383966	0.084821	0.041111	0.140311	0.014986	0.329453
Adj. R-squared	0.453118	0.354631	0.041241	-0.004550	0.099373	-0.031919	0.297522
Sum sq. resids	4.05E+10	3669.232	159.5735	964.0557	227484.7	10379.56	725588.3
S.E. equation	31065.66	9.346800	1.949197	4.791003	73.59553	15.72045	131.4379
F-statistic	19.22809	13.08900	1.946319	0.900352	3.427435	0.319494	10.31770
Log likelihood	-527.7735	-162.8764	-92.33368	-132.8032	-255.7362	-186.2732	-281.8339
Akaike AIC	23.58993	7.372286	4.237052	6.035697	11.49939	8.412142	12.65929
Schwarz SC	23.71038	7.492730	4.357497	6.156141	11.61983	8.532586	12.77973
Mean dependent	21793.88	0.146667	1.298222	2.714541	15.74317	3.012317	80.12164
S.D. dependent	42008.19	11.63479	1.990677	4.780140	77.54950	15.47540	156.8209

Determinant resid covariance (dof adj.)	1.25E+22
Determinant resid covariance	7.68E+21
Log likelihood	-1580.811
Akaike information criterion	71.81381
Schwarz criterion	73.21899
Number of coefficients	35

4) VECM Model 2

Sample (adjusted): 1972 2016
Included observations: 45 after adjustments
Standard errors in ( ) & t-statistics in [ ]

Cointegrating Eq:	CointEq1
GVA(-1)	1.000000
GIA(-1)	-6269.691
	(2576.07)
	[-2.43382]
FERTILISER CONS(-1)	-2985.958
	(1363.21)
	[-2.19038]
GFCF PRI(-1)	-357.6413
	(140.273)
	[-2.54961]
GFCF PUB(-1)	-70.43844
	(389.470)
	[-0.18086]
INSTITUTIONAL CRE...	-33.09640
	(44.9174)
	[-0.73683]
C	39863.23

Error Correction:	D(GVA)	D(GIA)	D(FERTILI...	D(GFCF PRI)	D(GFCF P...	D(INSTITUT...
CointEq1	-0.244065	-1.12E-06	9.59E-06	-9.43E-05	2.23E-05	-0.000789
	(0.07979)	(4.2E-06)	(9.9E-06)	(0.00016)	(3.2E-05)	(0.00026)
	[-3.05884]	[-0.26895]	[0.96753]	[-0.58238]	[0.69112]	[-3.00749]
C	21793.88	1.298222	2.714541	15.74317	3.012317	73.90345
	(5740.75)	(0.29993)	(0.71310)	(11.6482)	(2.32075)	(18.8815)
	[3.79635]	[4.32840]	[3.80668]	[1.35155]	[1.29799]	[3.91406]
R-squared	0.178707	0.001679	0.021306	0.007826	0.010986	0.173792
Adj. R-squared	0.159608	-0.021537	-0.001454	-0.015248	-0.012014	0.154578
Sum sq. resids	6.38E+10	174.0702	983.9673	262541.9	10421.71	689851.0
S.E. equation	38510.13	2.012000	4.783614	78.13850	15.56809	126.6612
F-statistic	9.356490	0.072335	0.936119	0.339166	0.477653	9.044996
Log likelihood	-537.9698	-94.29015	-133.2632	-258.9611	-186.3644	-280.6975
Akaike AIC	23.99866	4.279562	6.011696	11.59827	8.371750	12.56433
Schwarz SC	24.07895	4.359858	6.091992	11.67857	8.452046	12.64463
Mean dependent	21793.88	1.298222	2.714541	15.74317	3.012317	73.90345
S.D. dependent	42008.19	1.990677	4.780140	77.54950	15.47540	137.7547

Determinant resid covariance (dof adj.)	4.42E+20
Determinant resid covariance	3.36E+20
Log likelihood	-1446.568
Akaike information criterion	65.09191
Schwarz criterion	65.81457
Number of coefficients	18

5) VECM Model 3

Sample (adjusted): 1972 2016
Included observations: 45 after adjustments
Standard errors in ( ) & t-statistics in [ ]

Cointegrating Eq:	CointEq1	CointEq2
GVA(-1)	1.000000	0.000000
PERCAPITA FOODG...	0.000000	1.000000
GIA(-1)	-14221.69	0.125309
	(6772.45)	(1.07297)
	[-2.09993]	[0.11679]
FERTILISER CONS(-1)	2277.129	-0.482118
	(3575.29)	(0.56644)
	[0.63691]	[-0.85114]
GFCF PRI(-1)	-1240.354	0.211891
	(349.129)	(0.05531)
	[-3.55271]	[3.83076]
GFCF PUB(-1)	412.3515	0.110042
	(1005.61)	(0.15932)
	[0.41005]	[0.69070]
INSTITUTIONAL CRE...	61.15574	-0.038114
	(117.069)	(0.01855)
	[0.52239]	[-2.05494]
C	281252.4	-214.7239

Error Correction:	D(GVA)	D(PERCAP...	D(GIA)	D(FERTILI...	D(GFCF PRI)	D(GFCF P...	D(INSTITUT...
CointEq1	-0.388814	-9.71E-05	-5.91E-06	-5.16E-06	-0.000276	-2.80E-05	-0.000446
	(0.06620)	(1.9E-05)	(4.0E-06)	(9.9E-06)	(0.00016)	(3.3E-05)	(0.00027)
	[-5.87296]	[-5.17589]	[-1.46567]	[-0.52070]	[-1.75870]	[-0.84097]	[-1.62069]
CointEq2	-2490.189	-0.682132	-0.050231	-0.065732	-2.374634	-0.133636	0.356019
	(436.097)	(0.12358)	(0.02657)	(0.06524)	(1.03249)	(0.21897)	(1.81123)
	[-5.71018]	[-5.51966]	[-1.89073]	[-1.00757]	[-2.29991]	[-0.61028]	[0.19656]
C	23792.98	0.146667	1.298222	2.714541	17.65979	3.208317	80.12164
	(4765.28)	(1.35040)	(0.29030)	(0.71287)	(11.2821)	(2.39275)	(19.7915)
	[4.99299]	[0.10861]	[4.47197]	[3.80790]	[1.56529]	[1.34085]	[4.04829]
R-squared	0.456164	0.421351	0.086501	0.044679	0.124622	0.019940	0.315841
Adj. R-squared	0.430267	0.393796	0.043002	-0.000812	0.082937	-0.026729	0.283262
Sum sq. resids	4.29E+10	3446.555	159.2804	960.4687	240572.2	10820.75	740317.2
S.E. equation	31966.45	9.058744	1.947406	4.782081	75.68295	16.05107	132.7652
F-statistic	17.61459	15.29144	1.988543	0.982141	2.989637	0.427264	9.694621
Log likelihood	-529.0598	-161.4678	-92.29232	-132.7193	-256.9948	-187.2098	-282.2861
Akaike AIC	23.64710	7.309678	4.235214	6.031969	11.55532	8.453769	12.67938
Schwarz SC	23.76755	7.430123	4.355658	6.152413	11.67577	8.574213	12.79983
Mean dependent	23792.98	0.146667	1.298222	2.714541	17.65979	3.208317	80.12164
S.D. dependent	42350.52	11.63479	1.990677	4.780140	79.03120	15.84076	156.8209

Determinant resid covariance (dof adj.)	1.54E+22
Determinant resid covariance	9.48E+21
Log likelihood	-1585.550
Akaike information criterion	72.02445
Schwarz criterion	73.42963
Number of coefficients	35

6) VECM Model 4

Sample (adjusted): 1972 2016
Included observations: 45 after adjustments
Standard errors in ( ) & t-statistics in [ ]

Cointegrating Eq:	CointEq1
GVA(-1)	1.000000
GIA(-1)	1333.291
	(6282.12)
	[0.21224]
FERTILISER CONS(-1)	-7561.908
	(3314.66)
	[-2.28135]
GFCF PRI(-1)	-790.2096
	(326.546)
	[-2.41990]
GFCF PUB(-1)	-319.4228
	(945.391)
	[-0.33787]
INSTITUTIONAL CRE...	59.72199
	(111.678)
	[0.53477]
C	-153605.2

Error Correction:	D(GVA)	D(GIA)	D(FERTILI...	D(GFCF PRI)	D(GFCF P...	D(INSTITUT...
CointEq1	-0.082329	-5.14E-09	4.99E-06	-2.90E-05	6.35E-06	-0.000371
	(0.03434)	(1.7E-06)	(4.1E-06)	(6.8E-05)	(1.4E-05)	(0.00010)
	[-2.39756]	[-0.00299]	[1.23027]	[-0.42601]	[0.46581]	[-3.54214]
C	23792.98	1.298222	2.714541	17.65979	3.208317	73.90345
	(5997.90)	(0.30018)	(0.70846)	(11.8924)	(2.38270)	(18.2767)
	[3.96689]	[4.32476]	[3.83162]	[1.48496]	[1.34651]	[4.04359]
R-squared	0.117918	0.000000	0.034002	0.004203	0.005021	0.225878
Adj. R-squared	0.097404	-0.023256	0.011537	-0.018955	-0.018118	0.207875
Sum sq. resids	6.96E+10	174.3630	971.2028	273665.9	10985.47	646361.5
S.E. equation	40235.13	2.013692	4.752485	79.77671	15.98362	122.6037
F-statistic	5.748286	8.95E-06	1.513572	0.181487	0.216975	12.54677
Log likelihood	-539.9416	-94.32797	-132.9694	-259.8948	-187.5497	-279.2324
Akaike AIC	24.08630	4.281243	5.998639	11.63977	8.424433	12.49922
Schwarz SC	24.16659	4.361539	6.078935	11.72006	8.504729	12.57951
Mean dependent	23792.98	1.298222	2.714541	17.65979	3.208317	73.90345
S.D. dependent	42350.52	1.990677	4.780140	79.03120	15.84076	137.7547

Determinant resid covariance (dof adj.)	5.01E+20
Determinant resid covariance	3.82E+20
Log likelihood	-1449.403
Akaike information criterion	65.21792
Schwarz criterion	65.94059
Number of coefficients	18

7) Data Set for Model 1 and Model 2

Year	GVA	GFCF_Pub	GFCF_Pri	GIA	Fertiliser_Cons	Institutional_Credit_PA	Institutional_Credit_FA
1971	408256.540	66.455	152.176	38.200	13.611	123.318	118.433
1972	397408.210	71.825	162.023	38.430	16.083	132.409	126.912
1973	375004.960	95.691	151.833	39.060	17.070	160.817	153.753
1974	406559.920	81.147	148.645	40.280	16.710	123.166	122.789
1975	395400.670	78.095	167.260	41.740	15.673	119.293	118.162
1976	451392.020	82.430	148.594	43.360	16.893	147.402	143.379
1977	423879.740	115.467	166.057	43.550	20.384	181.975	188.158
1978	476771.850	123.824	179.901	46.080	24.884	170.147	173.008
1979	486154.240	131.402	188.443	48.310	29.273	208.057	210.240
1980	421252.350	141.317	200.340	49.210	30.989	208.969	222.094
1981	481403.590	152.965	179.074	49.780	31.950	209.462	229.694
1982	504799.040	136.475	133.168	51.410	34.326	229.760	248.158
1983	504056.990	136.786	150.370	51.830	37.056	223.191	231.516
1984	558517.380	134.463	168.362	53.820	42.939	233.564	235.715
1985	566811.460	129.179	153.766	54.530	46.566	263.436	270.930
1986	567943.500	114.547	152.219	54.280	47.485	301.680	305.427
1987	565600.350	114.597	171.805	55.760	49.005	301.736	302.304
1988	555743.070	120.493	242.441	56.040	51.448	333.714	341.418
1989	649673.390	104.211	212.720	61.130	60.567	303.871	296.699
1990	652207.560	87.993	227.856	61.850	63.467	336.917	332.032
1991	680256.340	83.799	390.148	63.200	67.547	280.425	279.175
1992	664200.930	76.910	255.179	65.680	69.842	274.034	267.999
1993	711332.330	82.412	339.312	66.760	65.452	271.883	254.211
1994	733997.190	88.891	267.126	68.260	66.279	303.160	288.866
1995	768922.720	94.841	229.762	70.650	72.128	324.804	317.721
1996	761233.420	94.068	225.492	71.350	74.018	380.004	371.273
1997	840849.030	85.126	251.685	76.030	75.504	385.708	363.507
1998	815526.910	71.727	282.603	75.670	85.203	407.654	382.939
1999	874004.450	75.421	326.383	78.670	87.647	411.517	384.242
2000	895083.360	82.911	502.154	79.220	95.907	576.325	524.266
2001	889097.110	77.069	468.042	76.190	90.117	602.805	547.433
2002	946891.730	93.650	605.422	78.370	92.334	644.920	587.643
2003	869336.740	91.882	586.907	73.060	92.553	811.572	750.867
2004	964218.560	99.121	488.512	78.040	88.575	913.112	870.059
2005	964751.440	135.238	487.747	81.080	96.276	1103.725	1061.847
2006	1020718.140	159.256	559.983	84.280	105.532	1434.996	1366.140
2007	1052993.220	189.534	631.026	86.750	112.543	1726.290	1643.534
2008	1121724.520	190.385	750.276	88.060	115.614	1614.415	1556.929
2009	1119183.570	166.737	803.472	88.900	127.524	1834.434	1800.179
2010	1105962.880	193.627	884.969	85.090	139.999	2628.110	2520.256
2011	1220690.990	159.792	986.506	88.940	142.261	2601.412	2541.724
2012	1309485.000	172.232	1125.020	91.790	141.931	2609.954	2609.954
2013	1328184.000	174.426	1003.383	92.240	131.481	2807.229	2819.885
2014	1400618.000	157.631	1133.456	95.760	121.833	2968.424	2918.355
2015	1388874.000	174.650	1064.513	96.750	128.951	3406.199	3240.422
2016	1388981.000	202.010	860.619	96.620	135.766	3728.792	3444.088

8) Data Set for Model 3 and Model 4

Year	GVA	GFCF_Pub	GFCF_Pri	GIA	Fertiliser_Cons	Institutional_Credit_PA	Institutional_Credit_FA
1971	545461.906	70.226	153.835	38.200	13.611	123.318	118.433
1972	540865.534	76.102	163.828	38.430	16.083	132.409	126.912
1973	517681.061	99.225	153.800	39.060	17.070	160.817	153.753
1974	545967.304	84.381	150.651	40.280	16.710	123.166	122.789
1975	546808.408	81.415	169.592	41.740	15.673	119.293	118.162
1976	607455.473	86.043	150.726	43.360	16.893	147.402	143.379
1977	574747.671	120.905	168.354	43.550	20.384	181.975	188.158
1978	612001.253	129.077	182.363	46.080	24.884	170.147	173.008
1979	628634.027	137.345	190.385	48.310	29.273	208.057	210.240
1980	552329.544	147.643	202.192	49.210	30.989	208.969	222.094
1981	611072.916	160.965	180.432	49.780	31.950	209.462	229.694
1982	637817.066	144.157	134.348	51.410	34.326	229.760	248.158
1983	634638.690	145.479	151.840	51.830	37.056	223.191	231.516
1984	688440.922	144.397	170.184	53.820	42.939	233.564	235.715
1985	698470.407	138.678	155.492	54.530	46.566	263.436	270.930
1986	700916.841	122.270	154.254	54.280	47.485	301.680	305.427
1987	697273.095	124.824	174.037	55.760	49.005	301.736	302.304
1988	685938.874	129.907	247.004	56.040	51.448	333.714	341.418
1989	781182.015	113.588	216.573	61.130	60.567	303.871	296.699
1990	797067.557	97.968	232.388	61.850	63.467	336.917	332.032
1991	824777.349	94.620	395.362	63.200	67.547	280.425	279.175
1992	810603.676	86.772	259.949	65.680	69.842	274.034	267.999
1993	857345.312	92.316	345.741	66.760	65.452	271.883	254.211
1994	882846.369	97.981	274.227	68.260	66.279	303.160	288.866
1995	922968.140	103.374	236.766	70.650	72.128	324.804	317.721
1996	916672.652	102.969	233.152	71.350	74.018	380.004	371.273
1997	1001123.685	94.178	260.549	76.030	75.504	385.708	363.507
1998	979434.404	81.540	293.998	75.670	85.203	407.654	382.939
1999	1037291.257	86.639	339.890	78.670	87.647	411.517	384.242
2000	1066583.218	93.073	526.864	79.220	95.907	576.325	524.266
2001	1066056.416	87.530	492.075	76.190	90.117	602.805	547.433
2002	1130115.235	105.066	638.677	78.370	92.334	644.920	587.643
2003	1055380.377	101.540	623.673	73.060	92.553	811.572	750.867
2004	1150406.498	114.303	518.010	78.040	88.575	913.112	870.059
2005	1152840.672	143.786	512.681	81.080	96.276	1103.725	1061.847
2006	1208284.977	169.803	588.092	84.280	105.532	1434.996	1366.140
2007	1243794.001	201.921	662.740	86.750	112.543	1726.290	1643.534
2008	1312283.228	200.357	790.860	88.060	115.614	1614.415	1556.929
2009	1309078.707	175.534	846.820	88.900	127.524	1834.434	1800.179
2010	1297555.764	203.913	932.652	85.090	139.999	2628.110	2520.256
2011	1411633.731	168.218	1039.688	88.940	142.261	2601.412	2541.724
2012	1501947.292	181.696	1185.282	91.790	141.931	2609.954	2609.954
2013	1524289.000	184.868	1069.998	92.240	131.481	2807.229	2819.885
2014	1609198.000	167.360	1206.355	95.760	121.833	2968.424	2918.355
2015	1605715.000	186.102	1144.813	96.750	128.951	3406.199	3240.422
2016	1616146.000	214.600	948.526	96.620	135.766	3728.792	3444.088