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# Growth of and Fluctuations in India's GDP and GDP Accruing from Agriculture During 1970-71 to 2019-20

**Dipankar Pradhan[1], and Debasish Mondal [2]**

[1] Assistant Professor, Faculty of Management and Commerce, The ICFAI University, Tripura, India
[2] Professor, Department of Economics, Vidyasagar University, West Bengal, India

Correspondence should be addressed to Dipankar Pradhan; Pradhandipankar10@gmail.com

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**ABSTRACT -** In India, agricultural sector output plays a significant role in the beginning phase of the growth of the economy because it absorbs the majority of employment. The agriculture sector includes crop production, livestock rearing, forestry, and fishing. However, the agricultural sector has experienced several fluctuations due to various factors, such as monsoon variability, natural disasters, government policies, and market conditions. These fluctuations have had a substantial influence on the overall economic growth of the nation. In this present paper, we try to find the linear growth and fluctuations around the linear of India's GDP and the agricultural sector output for 50 years long period from 1970-71 to 2019-20. The outcome of this study reveals that the annual average growth rate is 5.52% for GDP and 2.89% for the agricultural sector. The Coppock based year-to-year fluctuation around the trend is 0.00089 for gross domestic product and 0.00191 for the agricultural sector output. The overall fluctuation using the RSS-based method is 0.00520 for GDP and 0.00309 for GDPA.

**KEYWORDS -** Growth, Fluctuation, GDP, Agricultural GDP, CDVI, Coppock Index, Decadal GDP, JEL Classification O4, Q1.

## I. INTRODUCTION

One of the challenges of economic growth is managing its fluctuations. Economic growth is not always constant, and economies experience periods of boom and bust. These fluctuations can be caused by factors such as changes in consumer demand, changes in government policy, or external shocks such as natural disasters or wars. Managing these fluctuations is very necessary in order to keep the economy stable and avoid recessions. In the process of development, the role of agriculture gradually diminishes, although in the process agriculture tends to be modernized and transformed. The expansion of agricultural sector output has led to an overall increase in food production, which, in turn, led to employment generation. The Indian agricultural sector has witnessed a significant and remarkable change, starting with the first five-year plan and continuing from a period of acute food shortage to achieving self-reliance in food grain production throughout the years.

In this research, we consider a fifty-year period from 1970–71 to 2019–20 to find the nature of linear growth in India's GDP and the agricultural sector, as well as the different nature of fluctuations around the linear growth paths of India's GDP and GDPA.

Decadal growth and fluctuation are also calculated for these data sets. Fluctuation is identified through RSS-based measure, Coppock [6] measure and Cuddy and Della Valle [5] measure. RSS-based measure of fluctuation and Coppock's year to year measure of fluctuation give different views of fluctuation. Both indexes are high for short cyclical fluctuation, but Coppock's measure is lower than the RSS-based measure for long cyclical fluctuation. RSS-based measure explains average fluctuation relative to the mean value of $LnY_t$, whereas Coppock Index is based on S.D of ln $(Y_{t+1}/Y_t)$. These indexes are based on two different principles and are not readily comparable. Here we have used the modified Coppock index. This index is comparable to the RSS base index.

- ***Agriculture Sector***

In India, agricultural sector output plays a significant role in the beginning phase of the growth of the economy because it absorbs the majority of employment. The agriculture sector includes crop production, livestock rearing, forestry, and fishing. However, the agricultural sector has experienced several fluctuations due to various factors, such as monsoon variability, natural disasters, government policies, and market conditions. These fluctuations have had a substantial influence on the overall economic growth of the nation.

## II. LITERATURE REVIEW

Coppock [6] used relative changes as a means to facilitate comparisons across countries, commodities, or comparable entities. The postwar era saw the significant impact of trend influences, necessitating their elimination to effectively separate the fluctuations. Leith [4] has presented a comment on export instability. His paper explains that the mean instability index has significantly declined for developed and less developed countries, which is based on Coppock's [6] measure of instability. Cuddy and Della Valle[5] have provided an explanation for quantifying the extent of overall variation in relation to trend regression. The CDVI (Cuddy-Della Valle index) tries to remove the trend from the coefficient of variation (CV) by using the coefficient of determination ($\overline{R^2}$). Chand and Raju [7] have provided an explanation of an instability index. The estimation of instability is conducted for the overall agricultural sector and

its subsectors, in addition to for significant commodities, at both the national level and state level.

## III. OBJECTIVES

- To apply different types of fluctuation measuring methods on India's GDP and GDP coming from the agriculture sector, and to make a comparison not only among these two series but also among different types of fluctuation measuring methods for having different economic implications.
- To calculate the linear trend growth path of India's gross domestic product and GDPA.
- To find fifty years of trend growth from 1970-71 to 2019-20 and fluctuation around the trend growth path and also decadal growth and fluctuation evaluated.

## IV. DATA SOURCES

The data on India's GDP and GDP coming from the Agricultural sector is taken from secondary data source which is the RBI handbook of statistics. All data convert into 2011-12 base year constant price.

## V. METHODOLOGY

Growth of a time series variable is generally estimated from the semi-log-linear trend regression given by,

$$\ln Y_t = a + bt + e_t \quad (1)$$

In order to figure out the functioning of the model, it is necessary to separate out the constituent elements of the equation. This method also used by Pradhan and Mondal [3]. They dependent variable in the model is expressed as the natural logarithm of '$Y_t$', which is denoted as '$\ln(Y_t)$', while 't' is the independent variable representing time. The slope coefficient 'b' of the linear regression equation represents the constant growth rate. The error term '$e_t$' in equation (1) represents the random variability in the relationship between '$\ln(Y_t)$' and 't'. The error term is assumed to be normal distributed, which is characterized by a zero mean and a constant variance over time. The use of a logarithmic transformation of the variable '$Y_t$' in the model has several advantages. First, it allows for the capture of the exponential nature of economic growth, which is often observed in real-world data. Second, it helps to stabilize the variance of the variable over time, which is a common issue in growth data. Finally, it makes the interpretation of the slope coefficient 'b' easier since it represents the constant growth rate. To calculate the compound growth rate (CAGR) the same equation given in (1) is used, but the growth rate is calculated as: Growth rate = (exp (b)-1) *100

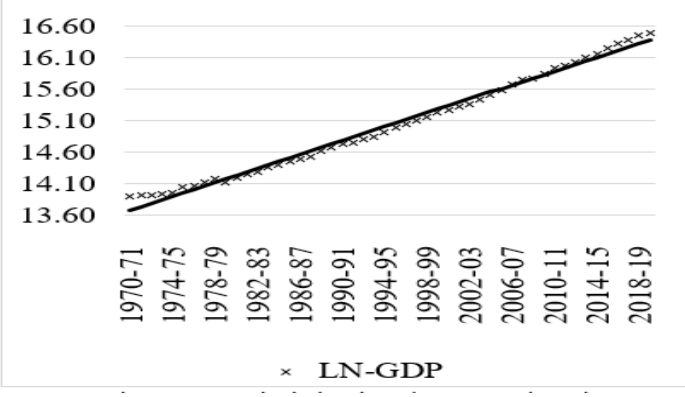
where 'exp' stands for exponent or anti-log of the argument and 'b' stands for the constant rate of exponential growth of the variable.

For steady and smooth economic growth, it is also important to find fluctuations around the linear trend growth path. For estimating relative average fluctuation, the common methodology is the RSS-based method. The RSS-based method is calculated using residuals from trend linear regression. The formula is written as $F_{RSS}= \sqrt{\frac{1}{T}\sum_{t=1}^{T} e_t{}^2}/\overline{\ln Y_t}$ . If we calculate Cuddy and Della Valle [5] instability index using R-square instead of adjusted R-square, the results are the same as the RSS-based measure of fluctuation. Coppock (1962) index for fluctuation is given by, $F_{COPPOCK} = Exp\ (S.D.(ln(\frac{Y_{t+1}}{Y_t})))$, this measurement is based on year-to-year fluctuation. RSS-based measure and Coppock's measure have given different views of instability [1].

RSS based measures give overall fluctuations from the trend line, so this method incorporates both year-to-year fluctuation, which is clearly explained by Coppock [6], and long-cycle fluctuations that occurs from breaks or business cycles. But the problem is that the Coppock method is not directly comparable with the RSS-based method, as both have different notions of principal. Pradhan and Mondal [1], Pradhan, Mondal [2] and Mondal and Mondal Saha [8], have suggested an adjusted Coppock measure of year-to-year fluctuation, whose method can be directly comparable with the RSS-based method. They also suggested estimating the average length of the full cycle based on RSS and the adjusted Coppock-based method, which gives us an approximate length of a full business cycle. The adjusted Coppock method can be written as: $F'_{COPPOCK} = (SD(ln(\frac{Y_{t+1}}{Y_t})))/(2(\overline{\ln Y_t}))$ and the approximate length of a full business cycle can be estimated by: $2(F_{RSS}/F'_{Coppock})^2$.

## VI. RESULTS AND DISCUSSION

In the results and discussion section, we are trying to present fluctuation from trend for India's GDP and GDP accruing from agricultural sector. For the agricultural sector, we have taken combined data from agriculture, forestry, and fishing data as it is available in secondary data sources over periods from 1970-71 to 2019-20.




Source: authors' own calculation based on secondary data, RBI-2023

Figure 1: Ln-GDP data points and linear growth from 1970-71 to 2019-20

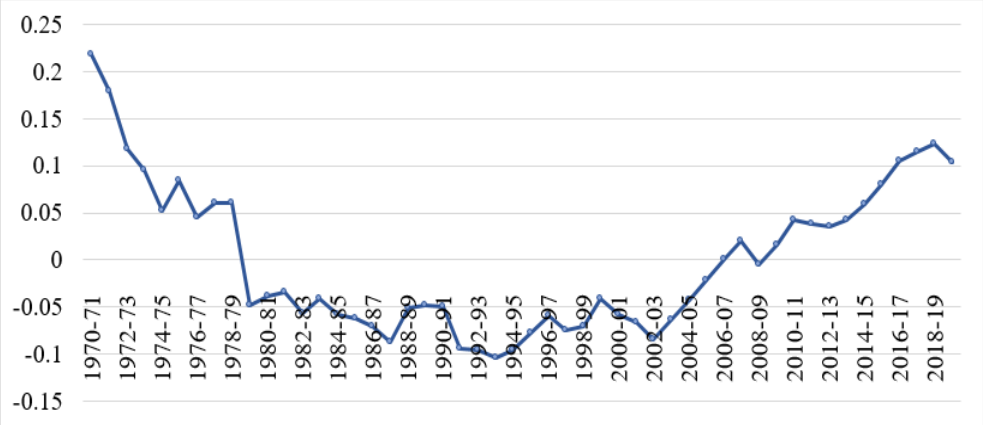
This line indicates a constant linear growth (the exponential annual growth rate (EAGR) is estimated at 5.52% percent per annum. with R-Square =0.9904, the adjusted R-Square = 0.9902. The F-value of 4969.75, with a corresponding P-value of 3.97E-50, indicates a significant linear trend exists in India's GDP (Table 1 and Figure 1).

Table 1: Results of linear regression of LN-GDP on time from 1970-71 to 2019-20

| | *Coefficients* | R Square | 0.9904 |
|---|---|---|---|
| Intercept | 13.6281 | Adjusted R Square | 0.9902 |
| Time (T) | 0.0552 | *F* | 4969.75 |
| Compound growth rate | 0.0567 | *Significance F* | 3.97E-50 |

Source: authors' own calculation based on secondary data, RBI-2023

The modified Coppock ($F'_{Coppock}$) measure of fluctuation of India's GDP is 0.00089, a small amount compared to the RSS-based measure of fluctuation. The approximate average length of the full cycle is 68.21 years, indicating a small amount of year-to-year fluctuation compared to overall fluctuation, as shown in Figure 2.




Source: authors' own calculation based on secondary data, RBI-2023

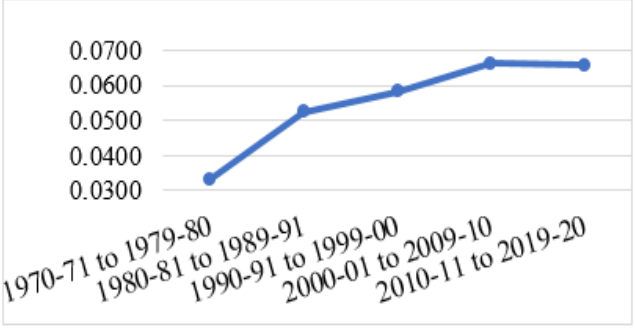
Figure 2: Data points of India's Residuals LN-GDP after de-trend: 1970-71 to 2019-20

Table 2: Results of fluctuation from linear trend of LN-GDP

| GDP | | | |
|---|---|---|---|
| $F_{Coppock}$ | 1.02716 | CDVI | 0.00526 |
| $F'_{Coppock}$ | 0.00089 | $F_{RSS}$ | 0.00520 |
| Average length of cycles | | | 68.21 (Years) |

Source: authors' own calculation based on secondary data, RBI-2023

The annual average growth rate of the GDP was 3.32 percent during the first sub-period (1970-71 to 1979-80). The results are presented in table 3. The figure for the second period or decade was 5.25%, and for the third period was 5.82%. The highest growth rate was achieved in the fourth decade (2000-01 to 2009-10), and the growth rate was 6.62%. The growth rate in the last decade or period was 6.58% (2010-11 to 2019-20).




Source: authors' own calculation

Figure 3: Data points of India's decadal GDP growth: 1970-71 to 2019-20

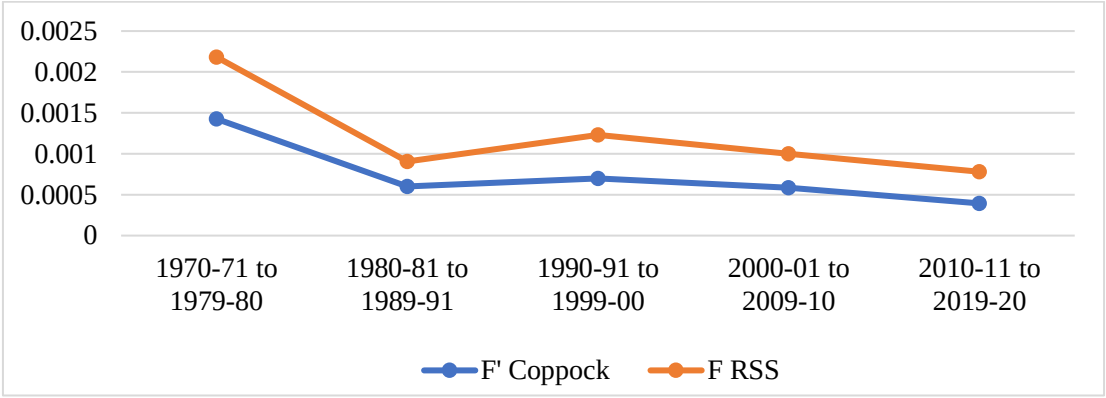
R square of all sub-periods is highly significant with the significance of F value. Figure 3 and table 3 show the highest growth rate in the fourth decade.

Table 3: Results of India's decadal GDP growth: 1970-71 to 2019-20

| | Annual average growth rate | R Square | Adjusted R Square | F-Value | Significance F |
|---|---|---|---|---|---|
| 1970-71 to 1979-80 | 0.0332 | 0.9067 | 0.8951 | 77.78 | 2.15E-05 |
| 1980-81 to 1989-91 | 0.0525 | 0.9925 | 0.9916 | 1060.01 | 8.63E-10 |
| 1990-91 to 1999-00 | 0.0582 | 0.9880 | 0.9865 | 657.46 | 5.74E-09 |
| 2000-01 to 2009-10 | 0.0662 | 0.9934 | 0.9925 | 1198.71 | 5.30E-10 |
| 2010-11 to 2019-20 | 0.0658 | 0.9955 | 0.9950 | 1786.73 | 1.08E-10 |

Source: authors' own calculation

In figure 4, this paper tries to present decade-wise $F'_{Coppock}$ and $F_{RSS}$ data points. The data points presented modified year-to-year fluctuation given by $F'_{Coppock}$ value continually decreased, and overall fluctuation given by $F_{RSS}$ also decreased over time. The fourth sub-period shows the difference between $F_{RSS}$ and $F_{Coppock}$ is high.




Source: authors' own calculation

Figure 4: Data points of India's decadal Residuals LN-GDP after de-trend: 1970-71 to 2019-20

In table 4, this paper presented India's GDP fluctuation from the trend decadal wise. CDVI and FRSS both index measure overall fluctuation from trend, and $F_{Coppock}$ and $F'_{Coppock}$ give year-to-year measures of fluctuation. We estimate the average approximate length of the full-length cycle on the basis of $F'_{Coppock}$) and $F_{RSS}$. As the difference between $F'_{Coppock}$ and $F_{RSS}$ high in the fourth decade compared to all other decades, the average length of the full business cycle maximum in the fifth decade is 7.9 years. Year to year and overall fluctuation highest in first sub period and lowest in last sub period.

Table 4: Fluctuation around linear trend for decadal LN-GDP using different methods

| | F Coppock | F' Coppock | CDVI | F RSS | Average length of cycles |
|---|---|---|---|---|---|
| 1970-71 to 1979-80 | 1.0408 | 0.00143 | 0.00232 | 0.00218 | 4.7 (Years) |
| 1980-81 to 1989-91 | 1.0175 | 0.00060 | 0.00096 | 0.00091 | 4.6 (Years) |
| 1990-91 to 1999-00 | 1.0211 | 0.00070 | 0.00131 | 0.00123 | 6.2 (Years) |
| 2000-01 to 2009-10 | 1.0183 | 0.00058 | 0.00106 | 0.00100 | 5.8 (Years) |
| 2010-11 to 2019-20 | 1.0128 | 0.00039 | 0.00083 | 0.00078 | 7.9 (Years) |

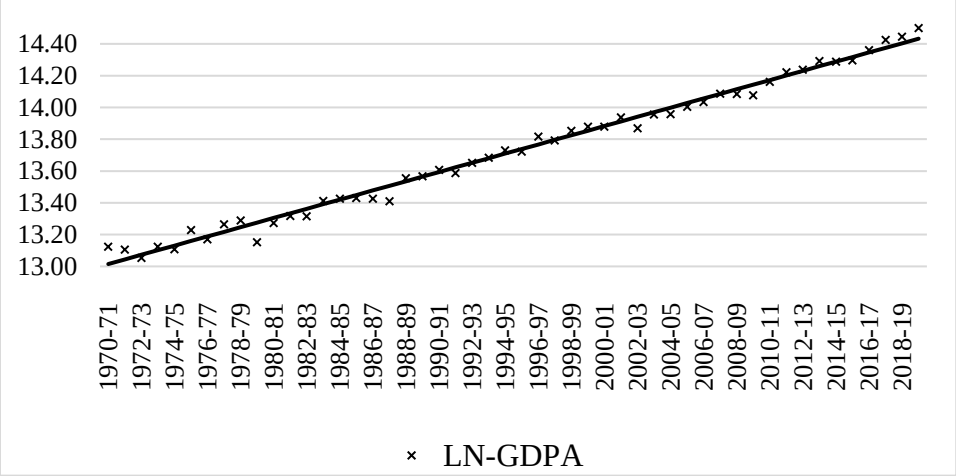
Source: authors' own calculation

The agricultural sector exhibits more volatility in its contribution to the GDP as compared to the other two sectors, such as the manufacturing sector and the service sector. Production in a country's agriculture sector mostly depends on climatic conditions or changing weather patterns, which can vary from year to year. Natural calamities like floods and droughts affect the agricultural sector of any country heavily. The results of linear trend regression are shown in Table 5. This line indicates a constant linear growth is estimated at 2.89 percent per annum. with R-Square =0.9898, the adjusted R-Square = 0.9896. The F-value of 4658.6, with a corresponding P-value of 1.84E-49, indicates a significant linear trend exists in India's agricultural sector output. The overall fluctuation (1-R-square value), which represents the amount of overall fluctuations around the trend line, is found to be 1.02%.

The regression equation for the agricultural sector is approximated as follows:

Ln (Agri) = 12.986 + 0.0289t

where "Ln (Agri)" represents the natural logarithm of the GDP coming from the agriculture sector and "t" denotes time. This equation suggests a consistent growth rate of 2.89 percent.




Source: authors' own calculation

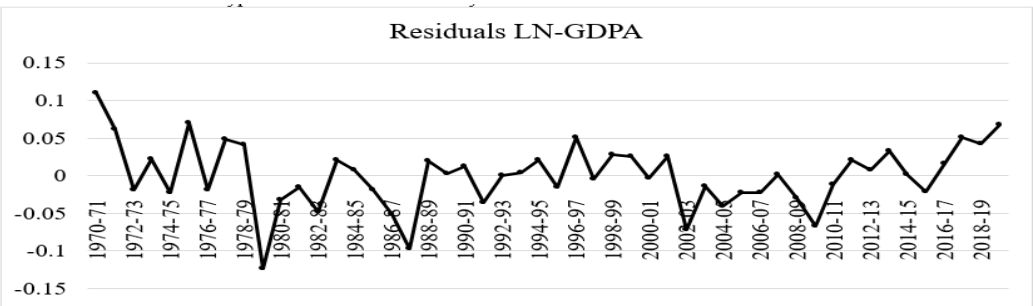
Figure 5: Data points (log values) of India's GDPA and their linear trend: 1970-71 to 2019-20

Table 5: Results of linear regression of LN-GDPA on time

| | Coefficients | R Square | 0.9898 |
|---|---|---|---|
| Intercept | 12.9860 | Adjusted R Square | 0.9896 |
| Time (T) | 0.0289 | *F* | 4658.6 |
| Compound growth rate | 0.0294 | *Significance F* | 1.84E-49 |

Source: authors' own calculation

Figure 5 shows very high year-to-year fluctuation ($F'_{Coppock}$) around the linear trend for the agricultural sector output. The present research shows the results of the fluctuation in India's GDP accruing from the agricultural sector. The amount of fluctuation, as indicated by R-square, is 1.02% of the total variation (as 1 – R-square = 0.0102), or we can say that RSS/TSS is found to be 1.02%. Another method of overall fluctuation is $F_{RSS}$, which is found to be 0.00309 for India's GDP coming from the agricultural sector (GDPA). Figure 6 presents much year-to-year fluctuation in comparison to India's overall GDP. On the other hand, we say that the data points of residual Ln-GDPA vary mostly from year-to-year other than some other types of fluctuation like cycle fluctuation, irregular fluctuation, etc. The adjusted R-square-based Cuddy and Della Valle's [5] measure of fluctuation is found to be 0.00312. Both RSS-based measures and CDVI-based measures are given average fluctuation from the mean of Ln-GDPA, but the only difference is that RSS-based measures depend on R-square and CDVI is based on adjusted R-square. To find out the approximate average length of the full business cycle, we use $2(F_{RSS}/F'_{Coppock})^2$, as denumerator $F'_{Coppock}$ close to numerator $F_{RSS}$, an approximate average length of the full cycle for India's GDP coming from the agricultural sector is 5.23 years.




Source: authors' own calculation

Figure 6: Data points of India's Residuals LN-GDPA after de-trend: 1970-71 to 2019-20

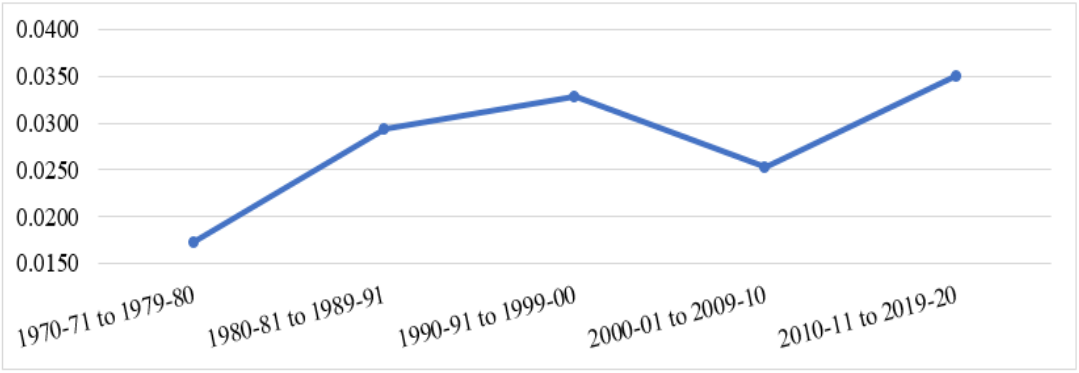
Table 6: Results of fluctuation of India's LN-GDPA using different methods: 1970-71 to 2019-20

| GDPA | | | |
|---|---|---|---|
| $F_{Coppock}$ | 1.05383 | CDVI | 0.00312 |
| $F'_{Coppock}$ | 0.00191 | $F_{RSS}$ | 0.00309 |
| Average length of cycles | | | 5.23 (Years) |

Source: authors' own calculation

The results and discussion section from figure 1 to figure 6 and table 1 to table 6 discussed the nature of India's GDP growth, fluctuation from the trend, decadal growth and decadal fluctuation from the trend. Now we have tried to discuss GDP coming from agricultural sector growth, fluctuation from trend, decadal growth and decadal fluctuation from the trend.

All decadal growth of India's GDP coming from the agricultural sector shows upward, as presented in figure 7. The annual growth rate of the GDP coming from the agricultural sector was 1.7 percent during the first sub-period or decade (1970-71 to 1979-80) presented in table 7. The figure for the second and fourth periods or decade is nearly close to 2.9 percent. The third and fifth period growth rate is close to 3.3 percent. The highest growth rate was achieved in the fifth sub period from 2010-11 to 2019-20




Source: authors' own calculation

Figure 7: Data points of India's decadal GDPA growth: 1970-71 to 2019-20

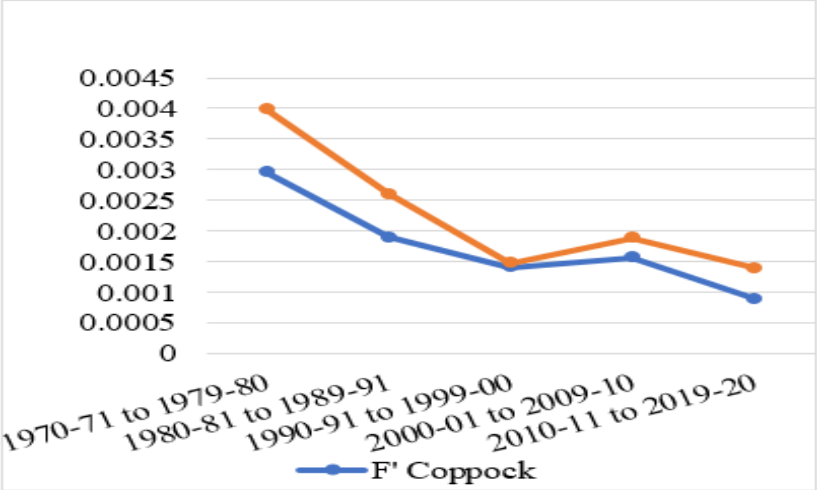
In table 7, we have presented the decadal annual average growth rate. In the first decade (1970-71 to 1979-80), the growth rate is the lowest, 1.72%. R square is also not significant at 1%, and it is significant at 5%. The highest growth rate achieved in the last decade (2010-11 to 2019-20) is 3.50%, which is a significance R square.

Table 7: Results of India's decadal GDPA growth: 1970-71 to 2019-20

| | Annual average growth rate | R Square | Adjusted R Square | F-Value | Significance F |
|---|---|---|---|---|---|
| 1970-71 to 1979-80 | 0.0172 | 0.4706 | 0.4044 | 7.11 | 2.85E-02 |
| 1980-81 to 1989-91 | 0.0293 | 0.8532 | 0.8349 | 46.50 | 1.35E-04 |
| 1990-91 to 1999-00 | 0.0328 | 0.9556 | 0.9501 | 172.32 | 1.08E-06 |
| 2000-01 to 2009-10 | 0.0253 | 0.8826 | 0.8680 | 60.17 | 5.45E-05 |
| 2010-11 to 2019-20 | 0.0350 | 0.9619 | 0.9571 | 201.72 | 5.88E-07 |

Source: authors' own calculation

In figure 8, we have presented the decadal wise year to year and overall fluctuation. Modified year-to-year fluctuation given by $F'_{Coppock}$ value continually decreased, and overall fluctuation given by $F_{RSS}$ also decreased. In the third sub period value of $F_{RSS}$ is very close to $F'_{Coppock}$, which indicates almost all fluctuation year-to-year types. In the first sub period difference between $F_{RSS}$ and $F'_{Coppock}$ is maximum.




Source: authors' own calculation

Figure 8: Data points of India's decadal Residuals LN-GDP after de-trend: 1970-71 to 2019-20

In table 8, this paper shows the outcomes for India's GDP coming from agricultural sector fluctuation around trend decadal wise. Here also fluctuation decreasing over time as GDP, which is a good sign for any economy. The average length of the full business cycle was highest in the last decade (2010-11 to 2019-20)

Table 8: Fluctuation around trend for decadal LN-GDPA using different methods

| | F Coppock | F' Coppock | CDVI | F RSS | Average length of cycles |
|---|---|---|---|---|---|
| 1970-71 to 1979-80 | 1.0810 | 0.0030 | 0.00423 | 0.00399 | 3.7 (Years) |
| 1980-81 to 1989-91 | 1.0524 | 0.0019 | 0.00276 | 0.00260 | 3.7 (Years) |
| 1990-91 to 1999-00 | 1.0396 | 0.0014 | 0.00157 | 0.00148 | 2.9 (Years) |
| 2000-01 to 2009-10 | 1.0448 | 0.0016 | 0.00201 | 0.00189 | 2.9 (Years) |
| 2010-11 to 2019-20 | 1.0261 | 0.0009 | 0.00148 | 0.00140 | 4.8 (Years) |

Source: authors' own calculation

We observed that the average approximate length of the full cycle for agricultural sector output is very low in comparison to GDP as a whole, which is 5.2 years. High Coppock (1962) index value (1.05383) in GDPA indicates very much year-to-year fluctuation. Cuddy and Della Valle index (1978) (CDVI) for GDPA is very low (0.00312), and a high Coppock index (1.05383) indicates fluctuation creates mainly year-to-year fluctuation and another type of fluctuation very less amount and high Coppock index value and low RSS and CDVI value indicates the approximate average length of the full cycle is low 5.2 years.

## VII. CONCLUSION

In our study, we have found the nature of the linear growth and fluctuation around the linear growth path in India's GDP and GDPA from 1970-71 to 2019-20. The annual average growth rate of India's GDP and GDPA is 5.52% and 2.89% respectively. For GDP and GDP coming from agriculture, the amount of residual is 0.96% and 1.02% of total variation and 99.04% and 98.98% is explained by a linear trend (growth) respectively. There are different types of fluctuation that arise in a data set, namely year-to-year fluctuation, cyclical fluctuation, seasonal fluctuation, irregular fluctuation, etc. Coppock (1962) has given a formula for measuring year-to-year fluctuations around the trend. For measuring overall fluctuations around the trend, the existing literature supports the RSS-based measure and the Cuddy and Della Valle [5] method (CDVI). The difference between the RSS-based method and the CDVI method is that the RSS-based method is considered R-square, while the CDVI method is considered adjusted R-square. CDVI-based and $F_{RSS}$ based fluctuation for agricultural sector output is found to be 0.00312 and 0.00309, respectively. $F_{RSS}$-based fluctuation for GDP is to be 0.00520. CDVI-based fluctuation for GDP is 0.00526. The modified Coppock ($F'_{Coppock}$) measure of fluctuation is 0.00089 and 0.00191 for GDP and GDP coming from agriculture. If these growth paths we extend, we get an approximate average length of the full business cycle for GDP and GDP coming from the agriculture. In that case, it is 68.21 years and 5.2 years.

## CONFLICTS OF INTEREST

The authors declare that they have no conflicts of interest.

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