Growth and Fluctuation in India's GDP and Sectoral GDP: 1970-71 to 2019-20

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Abstract

This paper investigates empirical issues regarding endogenous estimation of growth and fluctuations in India's GDP and its three important sectors, namely, the agricultural, the manufacturing and the service sectors in the period from 1970-71 to 2019-20. The methodology for evaluating the deterministic growth in a time series is well established. However, those for fluctuations around the growth path are diverse based on seemingly different aspects of fluctuations. Some existing tools and techniques are combined and modified to form a unified methodology to estimate fluctuation around the growth path. To evaluate the fluctuations, we compare the RSS-based method, the Cuddy and Della Valle (1978) method, and the Coppock (1962) method, and find the approximate average length of the full business cycle based on the results obtained from the RSS-based method and the modified Coppock (1962) method of fluctuation. The resulting estimates reveal that both the average exponential annual growth rate and the compound annual growth rate is the lowest for India's GDP coming from the agricultural sector (GDPA) and highest for GDP accruing from the service sector (GDPS). On the other hand, year-to-year fluctuation is lowest for GDPS and highest for GDPA, although overall fluctuation is the lowest for GDPA and the highest for GDPS. The approximate length of the full business cycle is the least for GDPA and the most for GDPS.

Keywords: *Growth, Fluctuation, GDP, Sectoral GDP.*

1. Introduction

As civilization progresses, human desires increase leading to evolution in economic activity in different spheres. Starting from primary activities such as fishing, animal husbandry, forestry, etc., agriculture has emerged in the process of evolution. Later, development in science and technology has taken place, leading to the evolution of the industrial sector. The expansion of the agricultural sector and manufacturing sector has led to the advancement of the service sector.

Economic growth is always a goal for human beings, society and a nation. Growth and fluctuations are two basic elements of almost all time series economic variables. These two elements make a series non-stationary. Growth in macroeconomic series arises from the increasing use of human resources, physical capital, natural resources, technology, innovation etc. It is also induced by different development policies pursued by the government. For obvious reasons, fluctuations around the growth path are also present in all these cases. Fluctuations of various types, viz., year-to-year, cyclical and irregular, are also observed to

vary in different regimes and different sectors. Cyclical fluctuation occurs due to business cycles observed in any market economy. Disturbances of several types also create some fluctuations. In the present work, we consider the period from 1970-71 to 2019-20 to analyse the nature of trend growth in India's GDP and sectoral GDP, namely, agricultural GDP (GDPA), manufacturing GDP (GDPM) and service GDP (GDPS) and the nature of fluctuation in the growth path of them. The data on India's GDP and sectoral GDP are obtained from the RBI handbook of statistics. All series are transformed by using relevant deflators to have the data at constant prices with 2004-05 as the base year. Fluctuation is identified through RSS-based measure, Coppock (1962) measure, and Cuddy and Della Valle (1978) measure and a comparative analysis among them is also performed. Through such comparisons the average lengths of cycles present in these series are also estimated.

Agriculture Sector

At the beginning of development, agriculture plays a key role in an underdeveloped country. The Indian agricultural sector has undergone tremendous transformation starting from 1st five-year plan over the years from severe food crisis to self-sufficiency in food grain production. The agricultural sector has also been diversified towards high-value commodities such as fruits and vegetables, poultry products, milk, fish, eggs, etc. in response to changing demand pattern fuelled by a growing economy and rising income levels.

Manufacturing Sector:

The manufacturing sector along with its forward and backward linkages, with its high employment potential, hold the key to a country's economic development. Since independence, India has achieved a reasonably good level of self-sufficiency in manufacturing various basic and capital goods. Growth in the manufacturing sector has the potentiality to elevate much of the Indian population above the poverty line by diverting a significant part of the workforce from low-wage agriculture. The manufacturing sector would create a more stable and prosperous India and, in turn, attract more business.

Service Sector:

The economic development of any country relies also on the growth and expansion of the third sector, namely, the tertiary or the service sector. The service sector in developing countries like India is growing at a faster rate in comparison to other sectors and at present it is contributing a major share of output, income, and employment. Even the productivity per worker has become higher in the service sector compared to the agriculture and industrial sectors. The service sector plays a dual role in driving economic growth. First, it directly affects consumers through the provision of direct consumer services. Secondly, it indirectly affects the agricultural and manufacturing sectors through the provision of productive services. Hence, this sector tends to play a major role in the economic development of any country.

Review of Literature:

Priscilla et al. (2017) have discussed on growth and fluctuation in area, production, and productivity of foodgrains at all India level. They have performed decade-wise growth rate analysis, instability index analysis and decomposition analysis of the performance of the agriculture sector. Kaur and Kiran (2008) have discussed on trends in output and inputs (labour, capital), partial productivity, and total factor productivity for India's manufacturing sector. They have tried to view the changes in the growth of output and inputs and productivity in the pre and post-reform periods. Ahluwalia (1985, 1991) examined total factor productivity growth (TFPG) in the manufacturing sector of India from 1959 to 1985. This study shows that during

the two decades of the sixties and the seventies, total factor productivity in the manufacturing sector has declined. However, there is also a finding that in the first half of the eighties, the productivitygrowth has improved. Latha and Shanmugam (2014) have analysed the growth of service sector in India in terms of development of health services and education services. They have concluded that the expansion of both the health and education sectors has made the advancement of the service sector. Balakrishnan & Parameswaran (2007) have discussed the turning point(s) of India's economic growth since the 1950s and the factors that has contributed to it. They have identified significant economic policy changes and tested whether they have succeeded in bringing about the growth shift. They used an exponential trend growth model of the type $\ln Y_t = a + bt$ to the time series of GDP and sub-sectors to estimate the breaks in growth rates over time. Chand and Raju (2008) have analysed the nature of instability in the production and yield of major crops before and after the implementation of economic reforms in Andhra Pradesh. The instability measured at the state-level data varies greatly from those at the disaggregated level in a large state like Andhra Pradesh. They have concluded that state-level analysis cannot give a complete picture of agricultural production shocks. Chand and Raju (2009) have observed the impact of green revolution technology on production variability by comparing the fluctuation in agricultural production from 1950-51 to 1964-65 with the period 1967-68 to 2001-02. Coppock (1962) have developed a log variance index of instability ($F_{Coppock}$) which several authors have used, for example, Leith (1970), Rangarajan and Sundararajan (1976), Anjum and Madhulika (2018) etc. He has introduced an important way of measuring fluctuation around the growth path of an economic time series. He has argued that if the series Y_t experiences a constant growth path then the ratios between Y_{t+1} and Y_t or the differences between $\ln Y_{t+1}$ and $\ln Y_t$ become constant and the standard deviation (S.D.) of these differences becomes zero, or the antilog of the standard deviation becomes one. Any fluctuation from the constant growth path makes the standard deviation greater than zero or its antilog greater than 1. Coppock has used this latter as the instability index. We denote this fluctuation index by $F_{Coppock}$. Thus, $F_{Coppock} = Exp\,(S.D.(ln(\frac{Y_{t+1}}{Y_t})))$.As is clear from the expression or from the conception about it, the measure is based on year-to-year fluctuation of $\ln Y_t$. The coefficient of variation (CV) is the most used and easily interpretable measure of the average variation of a non-trended data series. However, if the data exhibit any form of time trend, the coefficient of variation can be calculated only after some detrending method has been applied. Cuddy and Della Valle (1978) have given an index of instability which can be applied to non-trended, linear, or exponentially trended time series data. Anjum and Madhulika (2018) used Cuddy Della Valle Index and Coppock's instability index to calculate Agricultural instability in India.

2. Objectives, Data Sources and Methodology

Objectives

The present paper sets the following three objectives for itself.

To find out the annual average growth patterns of India’s gross domestic product (GDP) and sectoral GDP, viz., Agriculture, Manufacturing and Service and to make a comparison among them.

To apply different types of fluctuation measuring methods on India’s GDP and sectoral GDP, namely, Agriculture, Manufacturing and Service and to make a comparison not only among these four series, but also among different types of fluctuation measuring methods for having different economic implications.

To evaluate average length of cycles in these four series created through year-to-year fluctuations, cyclical fluctuations or breaks in the trend growth path due to policy changes. It can be noted in this context that year-to-year fluctuations create cycles of small length of two years, cyclical fluctuations create cycles of medium length of more than two to around ten years and breaks in the trend growth path create cycles of large length of normally more than ten years.

Data Sources:

The data on India's Gross Domestic Product (GDP) and its three important sectors, namely, the agriculture, the manufacturing and the service sectors are obtained from the RBI handbook of statistics. All series are transformed to have the data at constant prices with 2004-05 as the base year.

Methodology:

To measure annual average economic growth, we have used semi-log-linear trend regression given by,

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

where 'Y_t' is the relevant variable, 'ln' stands for natural logarithm, 'b' stands for the constant rate of exponential growth of the variable, 't' stands for time, and 'e_t' is the random error term.

To estimate the compound growth rate 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.

A relative measure of average fluctuation from the logarithmic trend is normally captured by the RSS-based measure of fluctuation given by the formula, $F_{RSS} = \sqrt{\frac{1}{T}\sum_{t=1}^{T} {e_t}^2}/\overline{ln\, Y_t}$. The RSS-based measure indicates overall fluctuation from trend growth. Some empirical works prefer to use the coefficient of variation (CV) as the measure of fluctuation which is an easily interpretable measure of the average variation measured relative to the mean value. For any variable, CV = Standard deviation/Mean value * 100. Although residuals measure the fluctuation, the coefficient of variation of residual cannot be calculated as the mean residual is 0. For measuring fluctuation, the coefficient of variation of lnY_t is taken first and then it is multiplied by the square root of $(1\text{-}R^2)$ to have $SD(e_t)/\overline{ln\, Y_t}$ and this is same as F_{RSS} obtained earlier. This measure is very close to that proposed by Cuddy and Della Valle (1978) in terms of coefficient of variation of lnY_tmultiplied by the square root of $(1\text{-}\bar{R}^2)$. Coppock (1962) measurement of the index of 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 give different views of instability.

The RSS base measure has zero lower limit, but no upper limit, it can go beyond one. The Coppock measure has a lower limit at one, and it has also no upper limit. F_{RSS} incorporates both the short cycles of year-to-year fluctuation given by $F_{Coppock}$ and the long cycles generated through business cycles or breaks. These two measures are not directly comparable, because

they have different lower limits and because they are rationalised in two different ways.However, after modification of the Coppock measure to $F'_{Coppock}$, it becomes comparable to F_{RSS}. The modified or adjusted Coppock measure of fluctuation is given by

$$F'_{Coppock} = (SD(ln(\frac{Y_{t+1}}{Y_t})))/(2(\overline{ln\, Y_t})).$$

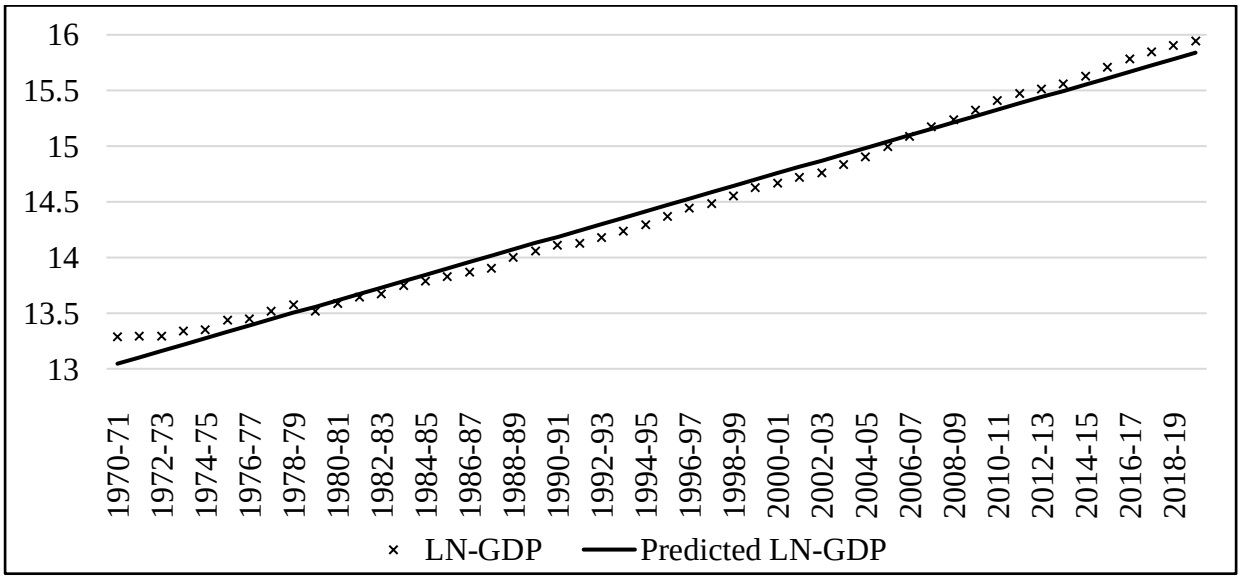
This index is comparable to the RSS base index and the average length of a full cycle can be estimated by, $2(F_{RSS}/F'_{Coppock})^2$. Mondal and Mondal Saha (2008) have depicted a detailed theoretical discussion on this adjustment.

Over-all fluctuation from trend can also be measured by $1\text{-}R^2$ vis-à-vis the RSS-based, and the Cuddy and Della Valle (1978) measures of fluctuation also giving overall fluctuation around the trend. The overall measure of fluctuation, represented by ($1\text{-}R^2$), indicates the ratio of the residual sum square to total sum square, which means it reflects the total residual based on the total sum square. Conversely, the RSS-based measure shows the residuals to average *Ln-Y*. In another way, the RSS-based measure is used to find an average relative share of fluctuation in the mean of ln-Y. We use both methods to measure overall fluctuation, but we specifically use RSS-based measures for comparison with the adjusted Coppock measure of fluctuation.

3. Results and Discussion:

This section presents annual average growth, compound annual growth rates and fluctuation of India's GDP and sectoral GDP over the period from 1970-71 to 2019-20. India has emerged as the fasted growing economy in the world. India has maintained rapid growth of GDP for most of the last two decades, leading to rising per capita incomes and a decline in absolute poverty. Here, with the help of above-mentioned methodologies we have tried to exhibit the current scenario of growth and fluctuation of India's Gross Domestic Product (GDP and sectoral GDP.

Figure 1.Data points (log values) of India's GDP and their linear trend: 1970-71 to 2019-20



Source: authors' own calculation

Trend analysis of India's Gross Domestic Product (GDP) (Figure 1 and Table 1) shows that the GDP has maintained a consistent positive growth rate throughout the period. We observe a linear trend with small fluctuation in the log values of GDP, as shown by the solid straight line indicating constant growth. The overall growth rate is 5.70% per annum and compound annual growth rate is 5.87% per annum, R-square =0.9868, Adjusted R-square = 0.9865, F-value = 3582.8 with P-value = 9.4E-47. The amount of fluctuation as indicated by R-square is 1.32% of total variation (as 1 – R-square = 0.0132). The ln-GDP data point in figure-1 indicates some systematic fluctuation in the data set.

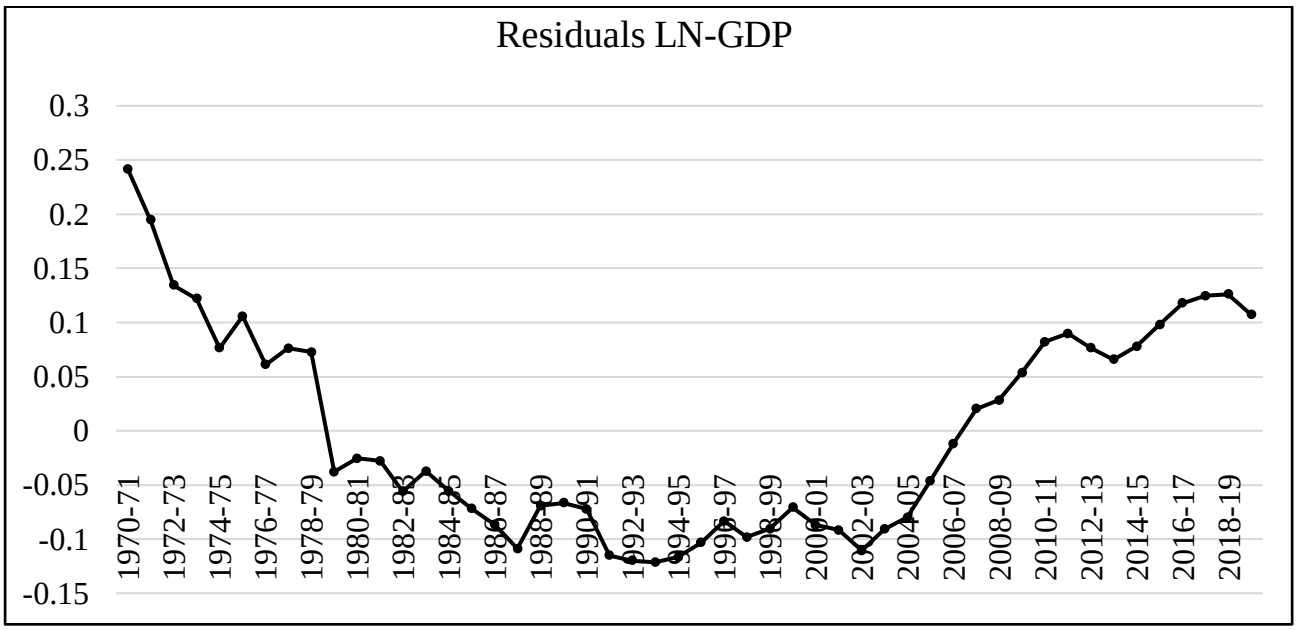
Table 1. Results of trend regression of India's LN-GDP for the period 1970-71 to 2019-20

	Coefficients	R Square	0.9868
Intercept	12.9889	Adjusted R Square	0.9865
Exponential Annual Growth Rate (EAGR)	0.0570	F-Value	3582.82
Compound Annual Growth Rate (CAGR)	0.0587	Significance F	9.37E-47

Source: authors' own calculation

The residuals around the trend are presented in Figure 2. The data points in Figure 2 indicate a large amount of overall fluctuation but a small amount of year-to-year fluctuation. This paper uses some existing methodologies for measuring fluctuation and tries to compare these methodologies. The detailed results of fluctuation are presented in Table 2. The RSS-based overall fluctuation around the trend for India's GDP is 0.00659, which differs slightly from the value of Cuddy and Della Valle (1978) measure of fluctuation which is given by $(CV(LnY) \times (1 - \bar{R}^2))$. Cuddy and Della Valle (CDVI) based overall fluctuation around the trend line of India's GDP is 0.00666. By replacing adjusted R-Square by R-Square in the CDVI method, the result of R-Square-based CDVI is equivalent to the RSS-based measures of fluctuation. As discussed in the methodology section, Coppock (1962) provides an interesting way to measure year-to-year fluctuations. The Coppock (1962) measure of fluctuation for GDP is 1.02825. The RSS-based and Coppock measures are not directly comparable (Mondal and Mondal Saha (2008)). The adjusted Coppock ($F'_{Coppock}$) measure can be used such comparison. As India's GDP has experienced a minor year-to-year fluctuation, the value of adjusted Coppock ($F'_{Coppock}$) measure turns out to be 0.00096 which is only 14.57% of F_{RSS}. The approximate average length of the full cycle is 93.5 years indicating a low proportion of year-to-year fluctuation in overall fluctuation.

Figure 2. Data points of residuals in India's detrended LN-GDP: 1970-71 to 2019-20



Source: authors' own calculation

Table 2. Results of fluctuation of India's LN-GDP using different methods: 1970-71 to 2019-20

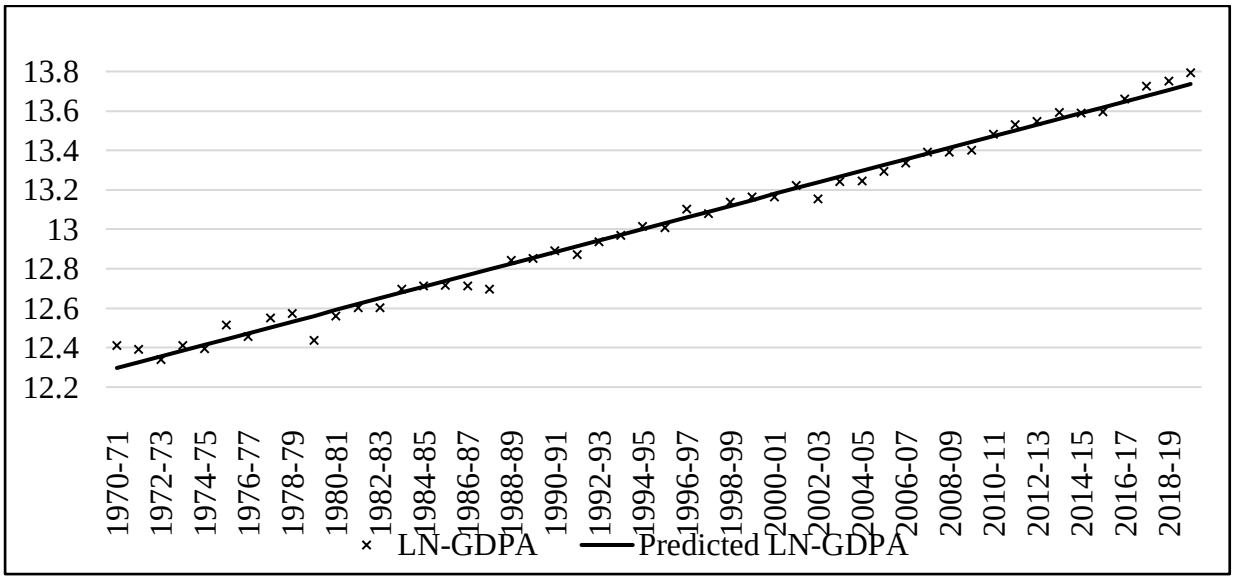
GDP			
$F_{Coppock}$	1.02825	CDVI	0.00666
$F'_{Coppock}$	0.00096	F_{RSS}	0.00659
Approximate average length of cycle			93.5 (Years)

Source: authors' own calculation

The GDP coming from the agriculture sector tends to fluctuate more than the manufacturing and service sectors. This is because the production of a country's agriculture sector is largely influenced by weather patterns, which can vary from year to year. Natural calamities such as floods and droughts can have a significant impact on the agricultural output of any country. The approximate linear trend for log values of India's GDP coming from agriculture (GDPA) is shown by the solid straight line in Figure 3. The results of linear trend regression are presented in Table 3. This line indicates a constant growth (the exponential annual growth rate (EAGR) is estimated at 2.94 percent per annum. The compound annual growth rate (CAGR) is estimated at 2.98 percent per annum with R-Square =0.9900, Adjusted R-Square = 0.9898, F-value = 4766.6 with P-value = 1.07E-49. The amount of fluctuation as indicated by R-square, is 0.99% of the total variation (as 1 – R-square = 0.0099).

The estimated line is: Ln (Agri) = 12.268 + 0.0294t, indicating a constant growth of 2.94 percent.

Figure 3. Data points (log values) of India's GDPA and their linear trend: 1970-71 to 2019-20



Source: authors' own calculation

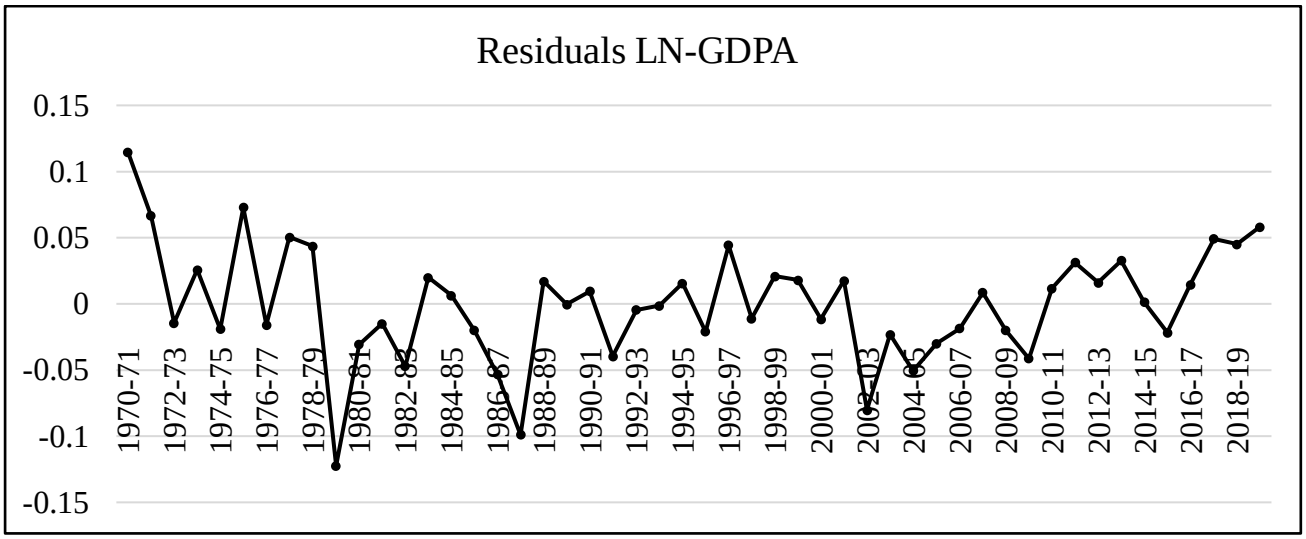
Table 3. Results of trend regression of India's LN-GDPA for the period 1970-71 to 2019-20

	Coefficients	R Square	0.9900
Intercept	12.2677	Adjusted R Square	0.9898
Exponential Annual Growth Rate (EAGR)	0.0294	F-Value	4766.62
Compound Annual Growth Rate (CAGR)	0.0298	Significance F	1.07E-49

Source: authors' own calculation

F_{RSS} is found to be 0.00327 for India's GDP coming from the agricultural sector (GDPA) (Table 4). Figure 4 presents a high amount of year-to-year fluctuation, which is also evident from the data points for LN-GDPA in Figure 3. The year-to-year fluctuation, measured by the Coppock (1962) method of fluctuation ($F_{Coppock}$), is found to be 1.05332 for GDPA. The adjusted Coppock measure of fluctuation is found to be 0.0020 for GDPA which is 61.16% of F_{RSS}. The overall fluctuation measured by Cuddy and Della Valle (1978) method of fluctuation is 0.00330. If we look at an approximate average length of the full cycle for India's GDP coming from the agricultural sector, it is estimated at 5.4 years. The overall fluctuation (F_{RSS} value) for GDPA is very small, and year-to-year fluctuation ($F'_{Coppock}$ value) contains a major part of overall fluctuation. This is also indicated by a small value of the length of the full cycle (5.4years).

Figure 4. Data points of residuals in India's detrended LN-GDPA: 1970-71 to 2019-20



Source: authors' own calculation

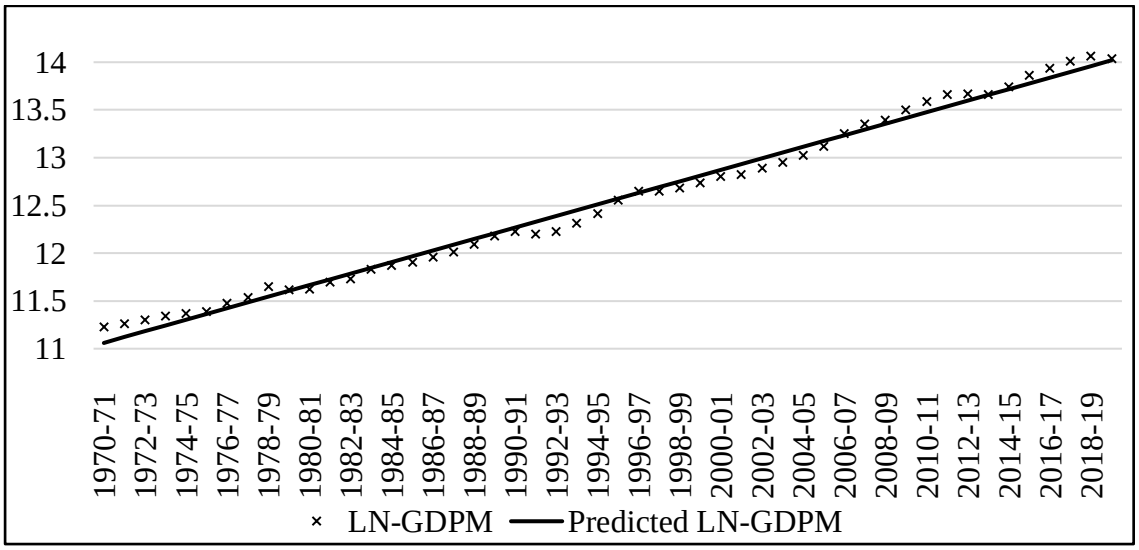
Table 4. Results of fluctuation in India's LN-GDPA using different methods: 1970-71 to 2019-20

GDPA			
$F_{Coppock}$	1.05332	CDVI	0.00330
$F'_{Coppock}$	0.00200	F_{RSS}	0.00327
Approximate average length of cycle			5.4 (Years)

Source: authors' own calculation

The technical progress of advanced and developed countries is generally thought to be associated with capital accumulation rather than labour. Understanding the growth process in developing countries is still not well understood. This paper examines the nature of the trend growth of India's GDP coming from the manufacturing sector from 1970-71 to 2019-20. Figure 5 depicts a consistent upward growth with some fluctuations in India's manufacturing sector GDP from 1970-71 to 2019-20, as demonstrated by the positive natural logarithmic values.

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



Source: authors' own calculation

The picture emerges (Figure 5 and Table 5) that the trend growth of India's GDP coming from the manufacturing sector (GDPM) is 6.04 percent per annum from 1970-71 to 2019-20. The compound annual growth rate is 6.23 percent per annum. The amount of residual sum square fluctuations to total sum square indicated by *RSS/TSS* is 0.88% (as 1 – R-square = 0.0088) for GDPM, and R-Square is 0.9912, Adjusted R-Square is 0.9910, F-value is 5392.8 with P-value = 5.69E-51.

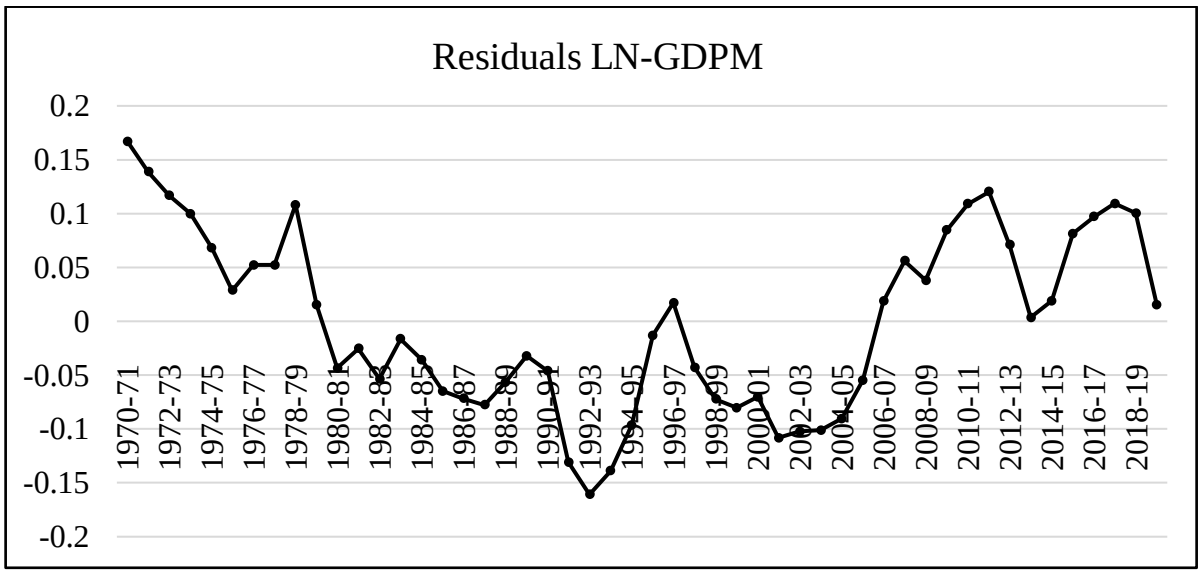
Table 5. Results of trend regression of India's LN-GDPM for the period 1970-71 to 2019-20

	Coefficients	R Square	0.9912
Intercept	10.9994	Adjusted R Square	0.9910
Exponential Annual Growth Rate (EAGR)	0.0604	F-Value	5392.79
Compound Annual Growth Rate (CAGR)	0.0623	Significance F	5.69E-51

Source: authors' own calculation

The overall fluctuation from the trend is measured by the RSS-based measure of fluctuation (F_{RSS}). This is found to be 0.00656 for India's manufacturing sector GDP (GDPM). The Cuddy and Della Valle (1978) method also measures the overall fluctuations from the trend, and it has been determined to be 0.00663. The year-to-year fluctuation is measured by the Coppock (1962) method ($F_{Coppock}$), which is found to be 1.04097 for GDPM. The adjusted Coppock measure of fluctuation is found to be 0.00160 for GDPM which is 24.39% of F_{RSS}. The approximate average length of the full cycle for GDPM is 33.6 years. Ln-GDPM data point in Figure 5 and residuals data point in Figure 6 also indicates some year-to-year fluctuations in the data set but not so much as compared to GDPA.

Figure 6. Data points of residuals in India's detrended LN-GDPM: 1970-71 to 2019-20



Source: authors' own calculation

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

GDPM			
$F_{Coppock}$	1.04097	CDVI	0.00663
$F'_{Coppock}$	0.00160	F_{RSS}	0.00656
Approximate average length of cycle			33.6 (Years)

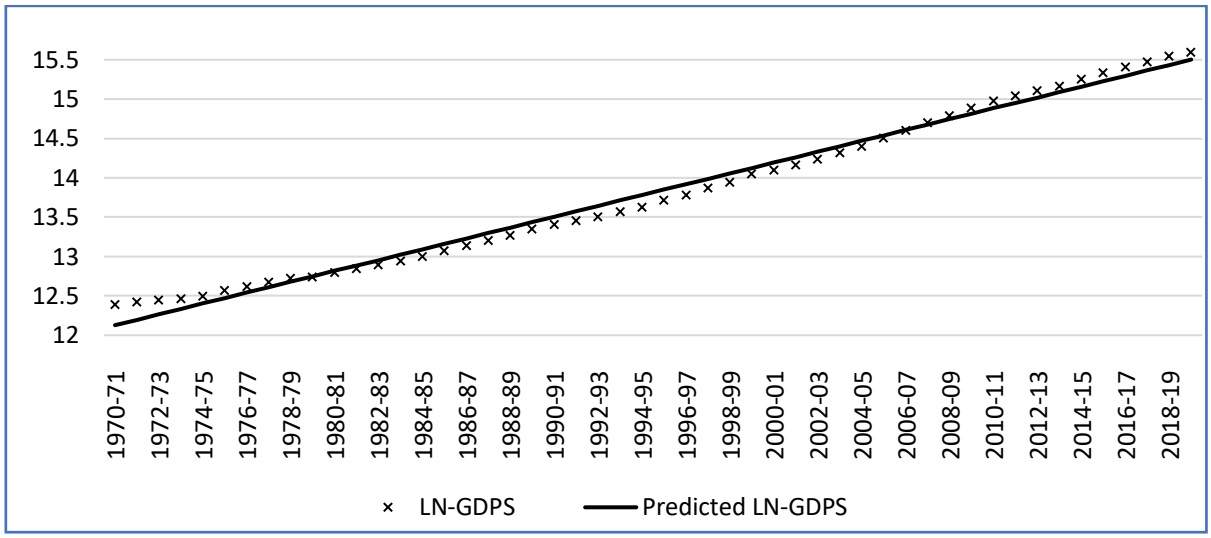
Source: authors' own calculation

The service sector, also known as the economy's tertiary sector, is expanding faster. It is one of the three main sectors of the economy. The 'Soft' component of the economy in the service sector includes all activities in which people contribute their knowledge and time to enhance productivity, potential performance, and sustainability.

India's service sector accounts for more than 53 percent of India's Gross Domestic Product (GDP) in 2021. There is a significant change in the sectoral contribution of each sector to India's GDP over the referred period extended back to 1950-51. In 1950-51, the primary sector contributed about 56.5 percent to India's GDP whereas the tertiary sector contributed 29.9 percent (Latha (2014) and MOSPI Bulletin 2021).

The trend growth of India's GDP coming from the service sector (GDPS) is presented in Figure 7. Ln-GDPS data points in Figure 7 display a systematic division from the linear trend line, indicating a small part of year-to-year fluctuation. Figure 7 shows an upward trend or positive growth of India's GDPS.

Figure 7. Data points (log values) of India's GDPS and their linear trend: 1970-71 to 2019-20



Source: authors' own calculation

Trend results of Table 7 show that for the variable GDP coming from the service sector (GDPS) linear trend explains 98.86 percent of its variability. This linear trend line indicates constant growth. The exponential annual growth rate (EAGR) is estimated at 6.89 percent per annum. The compound annual growth rate (CAGR) is estimated at 7.13 percent per annum with Adjusted R-Square = 0.9884, F-value = 4178.8 with P-value = 2.4E-48. The amount of fluctuation as indicated by the *RSS/TSS* is 01.14% (1 – R-square = 0.0114).
The estimated line is: Ln (GDPS) = 12.0591 + 0.0689t indicating a constant growth of 6.89 percent.

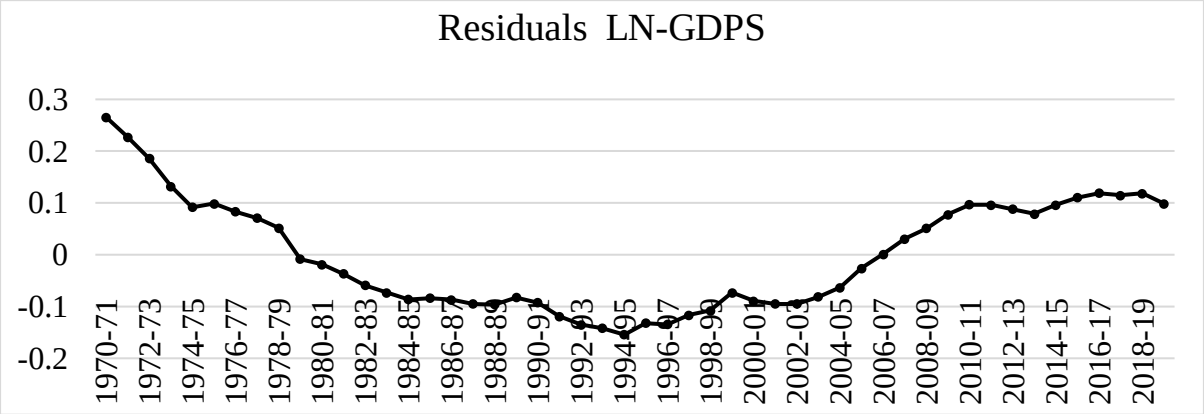
Table 7. Results of trend regression of India's LN-GDPS for the period 1970-71 to 2019-20

	Coefficients	R Square	0.9886
Intercept	12.0591	Adjusted R Square	0.9884
Exponential Annual Growth Rate (EAGR)	0.0689	F-Value	4178.84
Compound Annual Growth Rate (CAGR)	0.0713	Significance F	2.44E-48

Source: authors' own calculation

The fluctuation around the trend of India's GDPS is presented in Figure 8 and the results are presented in Table 8. The figure indicates a very small amount of year-to-year fluctuation and a large amount of overall fluctuation, which also shows that the approximate average length of the full business cycle is very long.

Figure 8. Data points of residuals in India's detrended LN-GDPS: 1970-71 to 2019-20



Source: authors' own calculation

Table 8. Results of fluctuation of India's LN-GDPS using different methods: 1970-71 to 2019-20

GDPS			
$F_{Coppock}$	1.02183	CDVI	0.00779
$F'_{Coppock}$	0.00078	F_{RSS}	0.00771
Approximate average length of cycle			194.6 (Years)

Source: authors' own calculation

The value of the RSS-based measure of fluctuation (F_{RSS}) is 0.00771, which indicates that the 0.771% total variability of the $\ln Y_t$ series is due to all types of fluctuations. The value of Coppock (1962) based method of fluctuation ($F_{Coppock}$) is found to be 1.02183, which is slightly greater than 1, indicating a part of the variability of $\ln Y_t$ series is due to year-to-year fluctuation. The value of the adjusted Coppock ($F'_{Coppock}$) based method is 0.00078. This value seems to be surprisingly low, causing the average length of the full cycle to be around 194.6 years. Hence, the prediction of the existence of a long cycle in the service sector output is true, and the observed period of 1970-71 to 2019-20 seems to be a part of a full cycle.

Before concluding it seems helpful if we make a comparative study between the sectors and with the overall economy. Summary results for such comparison are presented in Table 9. From the results we find that a high value of the adjusted Coppock index (0.00200) in proportion to a relatively low value of F_{RSS} index (0.00327) in GDPA indicates a very high year-to-year fluctuations as a proportion of overall fluctuation. On the other hand, a very low value of the adjusted Coppock index (0.00078) in proportion to a relatively high value of F_{RSS} index (0.00771) in GDPS indicates a very small amount of year-to-year fluctuations in proportion to RSS-based fluctuation. A high value of the adjusted Coppock index as proportion of F_{RSS} -based fluctuation indicates that the approximate average length of the full cycle for GDPA is very low at 5.4 years.

Table 9. Summary results on growth and fluctuation in India's GDPA, GDPM, GDPS and GDP

	EAGR	*Overall fluctuation (F_{RSS})*	*Year-to-year fluctuation ($F'_{Coppock}$)*	*Average length of cycles (Years)*
GDPA	0.0294	0.00327	0.00200	5.4
GDPM	0.0604	0.00656	0.00160	33.6
GDPS	0.0689	0.00771	0.00078	194.6
GDP	0.0570	0.00659	0.00096	93.5

Source: authors' own calculation

The F_{RSS} index for GDPS is high compared to GDP as a whole, GDPA and GDPM, and a low value of the adjusted Coppock index as proportion of F_{RSS} index indicates fluctuations are mainly of other types rather than year-to-year fluctuation. A low amount of adjusted Coppock index as proportion of F_{RSS} based fluctuation indicates that the approximate average length of the full cycle is very high at 194.6 years for GDPS.

4. Conclusion

In our study, we have examined the nature of the trend growth and fluctuation around the trend growth path in India's gross domestic product (GDP) and sectoral GDP, namely, the agricultural sector, manufacturing sector and service sector for the period 1970-71 to 2019-20. The annual exponential average growth rate (EAGR) of India's GDP coming from the agricultural sector is the lowest, which is 2.94 percent per annum. The highest annual exponential average growth rate is achieved for GDP coming from the service sector, which is 6.89 percent per annum. For GDP and GDP coming from the manufacturing sector, the EAGR are found to be 5.70 percent and 6.04 percent per annum respectively. The compound annual growth rates (CAGR) of India's GDP and GDP coming from the agriculture, manufacturing and service sector are 5.87%, 2.98%, 6.23% and 7.13% respectively. The compound annual growth rate (CAGR) for India's GDP coming from the agricultural sector is also the lowest, and the highest compound annual growth rate is achieved for GDP coming from the service sector. The overall fluctuation as measured by residual sum square to total sum square for GDP and the GDP accruing from agriculture, manufacturing, and service sectors are 1.32%, 1.00%, 0.88%, and 1.14% respectively. The overall fluctuation as measured by F_{RSS} and CDVI-based method are lowest for GDPA, which are 0.00330 and 0.00327 respectively, and highest for GDPS, which are 0.00779 and 0.00771 respectively. F_{RSS}-based fluctuation for GDP and GDPM are 0.00666 and 0.00663 respectively. CDVI-based fluctuation for GDP and GDPM are 0.00659 and 0.00656, respectively. If we use R-square instead of adjusted R-Square in the CDVI index, the result of R-square-based CDVI is the same as the F_{RSS}-based measure of fluctuation. The year-to-year fluctuations are measured by the Coppock method ($F_{Coppock}$), found to be 1.0282, 1.0533, 1.0409 and 1.0218 for India's GDP and GDPA, GDPM and GDPS, respectively. The adjusted Coppock ($F'_{Coppock}$) measure of fluctuation is 0.00096, 0.00200, 0.00160 and 0.00078 for GDP and GDPA, GDPM and GDPS, respectively. Based on the RSS base index proportion to the adjusted Coppock ($F'_{Coppock}$) measure, we get an approximate average length of the full business cycle (as $2(F_{RSS}/F'_{Coppock})^2$) for GDP and GDPA, GDPM and GDPS. The lengths of the full business cycle may be either in referred period or an extended period for GDP, GDPA, GDPM, and GDPS. In that case, it is 93.5 years, 5.4 years, 33.6 years and 194.6 years, respectively.

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