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Fluctuations in India's GDP and Manufacturing Output: An Analytical Approach

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Authors' contributions

This work was carried out in collaboration between both authors. Both authors read and approved the final manuscript.

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ABSTRACT

In India, the manufacturing sector has been a vital engine in driving economic growth, significantly contributing to employment and industrial development. This sector includes diverse activities such as production of consumer goods, heavy machinery, automobiles, textiles, and technology products. However, various factors—including changes in government policies, global trade dynamics, supply chain disruptions, and shifts in domestic demand—have contributed to periodic fluctuations within the sector, impacting overall economic stability. This study investigates the long-term linear growth and fluctuations around that trend for India's GDP and manufacturing output over a 50-year period, from 1970-71 to 2019-20. For measuring overall fluctuations around the trend, the existing literature supports the RSS-based measure and the Cuddy and Della Valle (1978) method

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(CDVI). The RSS-based method and the Coppock-based method are not directly comparable. After certain adjustments, the adjusted Coppock method becomes comparable to the RSS-based method. Based on both year-to-year fluctuations and overall fluctuations, we have calculated the approximate length of the full business cycle of a data set. The findings aim to shed light on the stability and growth patterns in manufacturing, providing insights into policy impacts and sectoral resilience amid economic cycles. The findings reveal an average annual growth rate of 5.52% for GDP and 6.08% for the manufacturing sector. The year-to-year fluctuation, using the adjusted Coppock index, is found to be 0.00089 for GDP and 0.00151 for the manufacturing sector GDP. Additionally, the overall fluctuation around the linear trend, calculated using the RSS-based approach, is 0.00520 for GDP and 0.00651 for manufacturing sector output.

Keywords: Fluctuation; GDP; manufacturing GDP; CDVI; coppock index.

JEL CLASSIFICATION: O4, Q1.

1. 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.

The manufacturing sector is a vital contributor to India's Gross Domestic Product (GDP), providing employment opportunities and contributing significantly to the country's economic growth (Goldar & Kumari, 2003). However, the manufacturing sector's GDP contribution has witnessed several fluctuations over the years, impacted by various factors such as government policies, technological advancements, and market conditions (Jyoti, 2021). However, the sector's contribution to the GDP declined in the 1970s and 1980s due to the inefficiencies of the public sector and the lack of incentives for private investment [8-10]. The liberalization, privatization and globalization of the Indian economy in the 1990s led to significant changes in the manufacturing sector, with a shift towards a market-driven approach and an increase in private sector participation (Pradhan & Mondal, 2024). So, there may be significant fluctuations present in India's manufacturing sector output. The fluctuations may be year-to-year or some other type, which cannot be ignored for stable future manufacturing sector growth.

2. LITERATURE REVIEW

Nayyar & Nayyar (2024) have highlighted the potential of industrial policy in fostering job creation, technological progress, and productivity gains for India. Drawing lessons from Asian industrialization, it suggests that policy coordination, innovation, and leveraging synergies between manufacturing and services are crucial for India's advancement amid global shifts like automation and market interdependence. Coppock (1962) introduced the use of relative changes (year to year) to calculate fluctuation in growth path. In the postwar period, prominent trend influences required removal to isolate fluctuations accurately. Leith (1970) contributed a commentary on export instability, noting that the average instability index had significantly decreased across both developed and developing nations, a finding based on Coppock's (1962) instability metric. Cuddy and Della Valle (1978) further advanced the measurement of overall variation by developing the Cuddy-Della Valle Index (CDVI), which adjusts the coefficient of variation (CV) by accounting for trend effects through the adjusted r square. Chand and Raju (2009) discussed an instability index, calculating instability for the agricultural sector, its subsectors, and key commodities at both national and state levels. Pradhan & Mondal (2023) have discuses growth and fluctuation measing method to calculated Indias GDP.

2.1 Objectives

- To find out different types of fluctuation measuring methods, compare the analysis of these methods and find out the fluctuation around the linear trend growth of India's GDP and one major good producing sector of GDP which is manufacturing sector.

During the past 50 years (from 1970–71 to 2019–20), India's GDP and its major goods-producing sectors, namely the manufacturing sector, have grown steadily. GDP growth is a key pillar of an economy. Proper growth measures assist policymakers in formulating future policy recommendations. In an economy where growth is an important element, reducing fluctuation is also important for steady growth. In this paper, we have endeavoured to identify the fluctuations that occur around the trend of linear growth.

This study aims to apply different methods of measuring fluctuations to India's GDP and its major goods-producing sector, namely the manufacturing sector, and to make comparisons not only between these two series but also among the various fluctuation measuring methods to derive different economic implications.

To evaluate the 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.

Finally, calculate the fluctuations around the linear trend growth path of India's gross domestic product and its one major good sector, namely the manufacturing sector.

2.2 Methodology

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 $F_{RSS}= \sqrt{\frac{1}{T}\sum_{t=1}^{T} {e_t}^2} / \overline{ln\, Y_t}$. The RSS-based measure indicates overall fluctuation from trend growth. Some empirical work uses the Coefficient of Variation (CV) of residuals as CV = Standard deviation/Mean value * 100. This measure provides a straightforward and interpretable indication of the average variance in a non-trended data series. But the literature uses the coefficient of variation (CV) of residuals in a little bit different form; they have taken the mean value of lnY_t because all we know is that the mean value of the residual is zero, so we cannot estimate the coefficient of variation using the mean of the residual. Though this method in the exiting literature is known as the coefficient of variation of error term, it uses the mean value of lnY_t. The calculation of the coefficient of variation of residuals is only possible if a detrending approach has been implemented. The RSS-based measure is very close to the coefficient of variation of e_t multiplied by the square root of (1-$\bar{R}^2$) as proposed by Cuddy and Della Valle (1978), where $\bar{R}^2$ is adjusted R square. If we calculate Cuddy and Della Valle (1978) instability index using R-square instead of adjusted R-square, the results are the same as the RSS-based measure of fluctuation. The methodology of average year-to-year fluctuations was given by Coppock (1962). The average year-to-year fluctuations can be written as: $F_{Coppock} = Exp\ (S.D.(ln(\frac{Y_{t+1}}{Y_t})))$, this measurement is based on year-to-year fluctuation. RSS-based measure and Coppock's measure have given different views of instability.

The RSS base measure has no upper limit, has a zero lower limit, and can go beyond one. The Coppock measure has a lower limit at one, and it has no upper limit. 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 (1962), 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. Mondal and Mondal Saha (2008) 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: $2(F_{RSS}/F'_{Coppock})^2$. Which will help us to find put the average length of a full cycle. Mondal and Mondal Saha (2008) obtained a detailed theoretical discussion on this adjustment. We have tried to find out fluctuations around the linear trend line of India's GDP and major sector of GDP, namely the manufacturing sector and tried to do a comparative analysis of results obtained from different methodologies.

3. RESULTS AND DISCUSSION

In the results and discussion section, we are trying to present fluctuation from trend for India's GDP and its one major goods producing sector of GDP, namely, the manufacturing sector sector. We shall try to explain overall average fluctuation deviation from the mean value of 'ln' of the dependent variable, year-to-year fluctuation, and finally, based on some methods, we shall explain the average length of a full business cycle.

3.1 The Nature of the Fluctuation around the Linear Trend of India's GDP

We expect there to be some fluctuations around the trend of linear growth in GDP, but it is crucial to understand the nature of these fluctuations. There are so many types of fluctuations that may accrue, but some are manageable by changing policy, and some are not. So, in this section, we have tried to find the nature of fluctuations around the linear trend growth path of India's gross domestic product. Fluctuations around the linear growth of India's GDP are expected to be part of the economic cycle, and the country has shown some economic shocks and high growth as well. However, it is essential to address the different types of fluctuation around the linear trend that can contribute to explaining the causes of economic slowdowns, such as nature calamities, droughts, oil price hikes, etc.

The residual after the trend for India's gross domestic product is presented in Fig. 1. The data point in Fig. 1 shows less year-to-year fluctuation compared to overall fluctuation; in other words, we can say that the residual Ln-GDP data points show some other types of fluctuation, such as seasonal and cyclical fluctuations, in addition to year-to-year fluctuation.

In the present research, we use RSS-based and CDVI-based methods to measure overall fluctuations, and for measuring year-to-year fluctuations, we use Coppock and adjusted Coppock-based methods to to find fluctuation in India's GDP and GDPM. The total overall fluctuation from the trend, measured by $1-R^2$, is found to be 0.0096 (i.e., 1−0.9904). Detailed results of fluctuations in the linear trend growth for India's gross domestic product (GDP) are presented in Table 1.

The RSS-based measure of fluctuation, which gives the overall fluctuation around the trend based on the mean of Ln-GDP, has a value of 0.00520 for India's GDP. This is slightly different from the Cuddy and Della Valle (1978)-based measure of fluctuation for India's GDP. Both the RSS-based measure and the Cuddy and Della Valle (1978) method indicate overall fluctuation. Another measure of overall fluctuation, $(1-R^2)$, represents the ratio of residual sum squares to the total sum of squares, capturing the total residual based on the total sum of squares. In contrast, the RSS-based and the Cuddy and

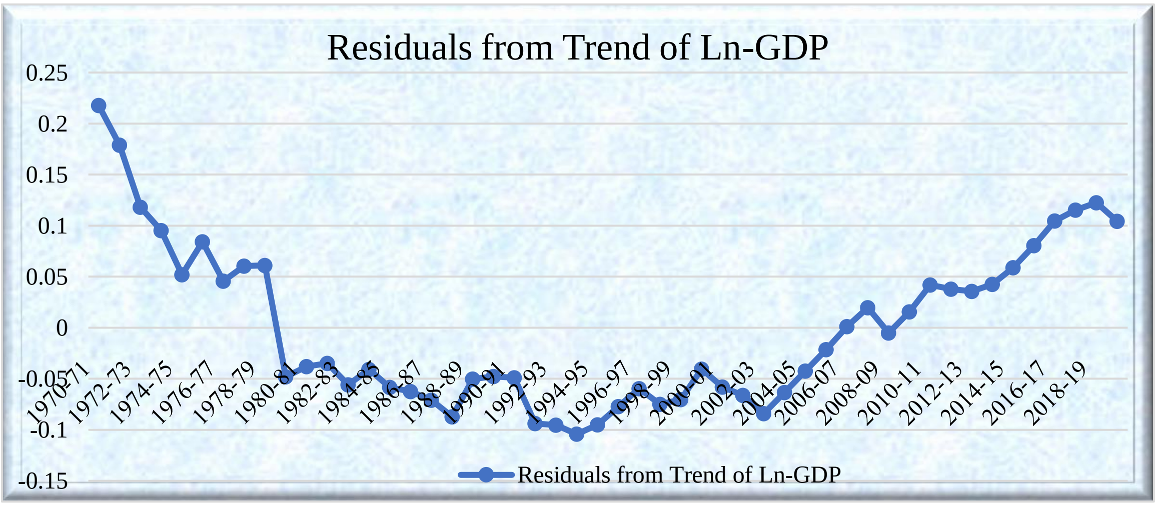

Fig. 1. Fluctuations around the linear growth of India's GDP
Source: Own calculation based on the RBI handbook statistics, 2023

Table 1 Results of linear trend growth and fluctuations around the linear path of India's GDP

GDP			
	Coefficients	**R Square**	**0.9904**
Intercept	13.6281	Adjusted R Square	0.9902
Time (T)	0.0552	Standard Error	0.0799
F value	4969.75	Significance F	4E-50
$F_{Coppock}$	1.02716	CDVI	0.00526
$F'_{Coppock}$	0.00089	F_{RSS}	0.00520
Average length of cycles			68.21 (Years)

Source: Own calculation based on the RBI handbook statistics, 2023

Della Valle (1978) methods use the residual sum square ratio to the mean of Ln-Y, representing total residual based on Ln-Y. Therefore, the RSS-based, Cuddy and Della Valle (1978), and overall fluctuation measure by 1-R^2 methods all indicate overall fluctuation, with the Cuddy and Della Valle (1978) proposed measure of fluctuation given by CV× (1-$\bar{R}^2$)). The CDVI measure of fluctuation for India's GDP is 0.00526, indicating the overall average fluctuation from the mean of Ln-GDP in the detrended dataset. If we use R-Square instead of adjusted R-Square in the CDVI method, the results of the R-Square-based CDVI are the same as the RSS-based measure of fluctuation. The year-to-year measure of fluctuation is given by Coppock (1962), with the Coppock-based measure of fluctuation calculated as 1.02716. Since the RSS-based and Coppock-based measures operate on different principles, they are not directly comparable. Consequently, the adjusted Coppock (F'_{Coppock}) measure of fluctuation for India's GDP is 0.00089, which is relatively low compared to the RSS-based measure of fluctuation. In other words, the year-to-year average fluctuation from the mean of Ln-GDP is very low compared to the overall average fluctuation of Ln-GDP.

If we divide the overall average fluctuation by the year-to-year average fluctuation, we can find the approximate length of a full business cycle. The approximate average length of the full cycle is 68.21 years; the large length of the full business cycle indicates a small amount of year-to-year fluctuation compared to overall fluctuation, as shown in Fig. 1.

In this section, we discussed fluctuations from the linear trend of Ln-GDP. We use the 1-R square to calculate the total fluctuation after linear trend regression. We also notice year-to-year fluctuations in Ln-GDP. Finally, we determine the average duration of a complete business cycle. Now we will discuss the fluctuations around the linear trend in India's agricultural sector output.

3.2 The Nature of Fluctuations around the Linear Trend of India's GDP Coming from the Manufacturing Sector

The manufacturing sector plays an extremely important role in boosting the GDP growth of a nation, and as a crucial contributor, it is also important to know the nature of fluctuations around the linear trend of the manufacturing sector. Less fluctuation in the manufacturing sector may lead to more consistent and steady economic growth in any economy. In order to promote the expansion of the manufacturing sector, the government will need to address the roots of structural obstacles that prevent economic growth, especially insufficient infrastructure, complex regulations, problems facing openness to the world, and skill shortages, which may create fluctuations and breaks in the linear trend growth path. To reduce fluctuations in the manufacturing sector, the government should also focus on encouraging innovation, promoting research and development, enhancing trade openness, and increasing foreign exchange reserves. With the right policies and reforms, the manufacturing sector can continue to be a major contributor to India's economic growth with less fluctuation.

In Fig. 2 and Table 2, the present research shows the fluctuation data points after the detrended ln-data series. The amount of residual sum square compared to total sum square, as indicated by R-square, is 0.93% of total variation (as 1 – R-square = 0.0093). Another annual average fluctuation from the trend is measured by the RSS-based measure of fluctuation (F_{RSS}). This is found to be 0.00651 for India's manufacturing sector GDP (GDPM). The overall fluctuation from trend is also measured by the adjusted R-square-based Cuddy and Della Valle (1978) measure (CDVI), which is found to be

0.00657. Both the RSS-based measure and the CDVI-based measure give overall fluctuations, but the former is based on R square and the latter is based on adjusted R square. The year-to-year fluctuation is measured by the Coppock (1962) measure of fluctuation ($F_{Coppock}$), found to be 1.04036 for GDPM. The adjusted Coppock measure of fluctuation is found to be 0.00151 for GDPM. The Coppock-based measure and the adjusted Coppock-based measure both are year-to-year fluctuations, but in the adjusted year-to-year fluctuation, we divide from the mean of Ln-GDP and lower limit at zero because to compare with the RSS-based measure of fluctuation. In the other way, we say that the adjusted Coppock measure value is 0.00151, whereas the RSS-based measure value is 0.00651. The difference between these two is high in comparison to GDPA, but not so high as these differences in GDP. The average approximate length of the full business cycle is calculated based on RSS and adjusted Coppock-based measures of fluctuation. The approximate average length of the full cycle for GDP accruing from the manufacturing sector is 37.14 years. The average approximate length of the full cycle in GDPM is greater than in GDPA but less than in GDP. In another way, we can explain that year-to-year fluctuation is less amount in comparison to overall fluctuation from GDPA and higher than GDP.

This section of the research provided a description of the fluctuations that were observed in India's Gross Domestic Product (GDP) that are specific to the manufacturing sector. Year-to-year and overall fluctuations have been identified. The average length of the full cycle has been determined based on the observed fluctuations. In the next section, the research clarifies the characteristics of the fluctuations based on a comparative analysis between two data series, using different methods of estimating fluctuations around the trend line.

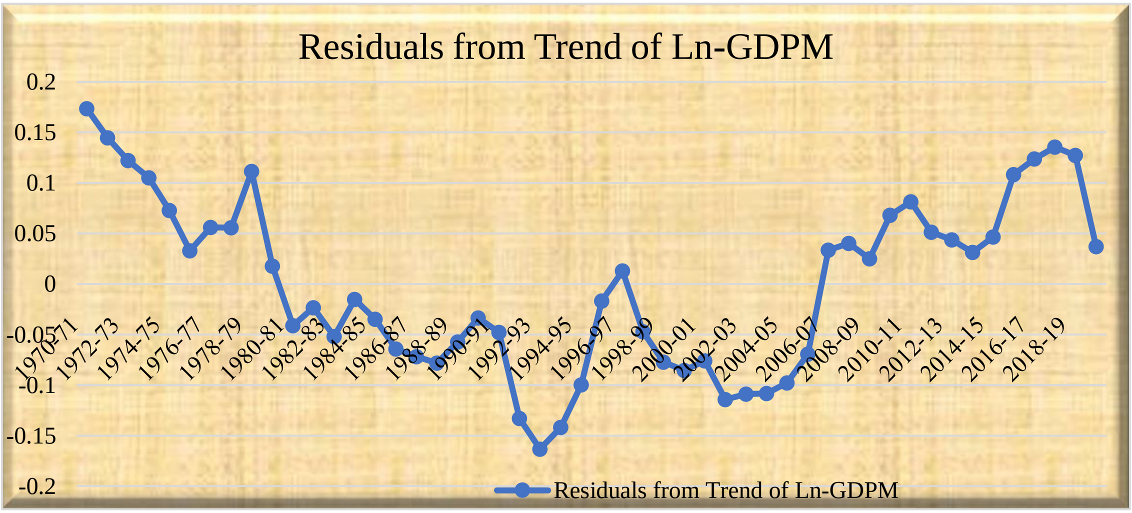

Fig. 2. Fluctuations around the linear growth of India's GDP coming from the manufacturing sector

Source: Own calculation based on the RBI handbook statistics, 2023

Table 2. Results of trend growth and fluctuations around the linear path of India's GDP coming from the manufacturing sector

GDPM			
	Coefficients	**R Square**	**0.9907**
Intercept	11.5524	Adjusted R Square	0.9905
Time (T)	0.0608	Standard Error	0.0870
F value	5089.60	Significance F	2.25E-50
$F_{Coppock}$	1.04036	CDVI	0.00657
$F'_{Coppock}$	0.00151	F_{RSS}	0.00651
Average length of cycles			37.14 (Years)

Source: Own calculation based on the RBI handbook statistics, 2023

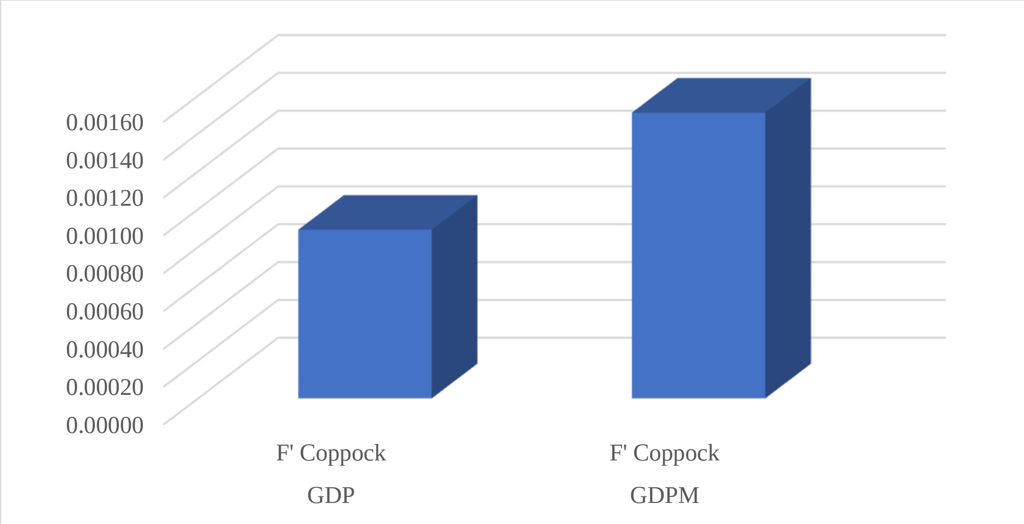

Fig. 3. Comparative analysis of fluctuations around the linear growth of India's GDP and GDP coming from manufacturing sector using $F'_{Coppock}$ method

Source: Own calculation based on the RBI handbook statistics, 2023

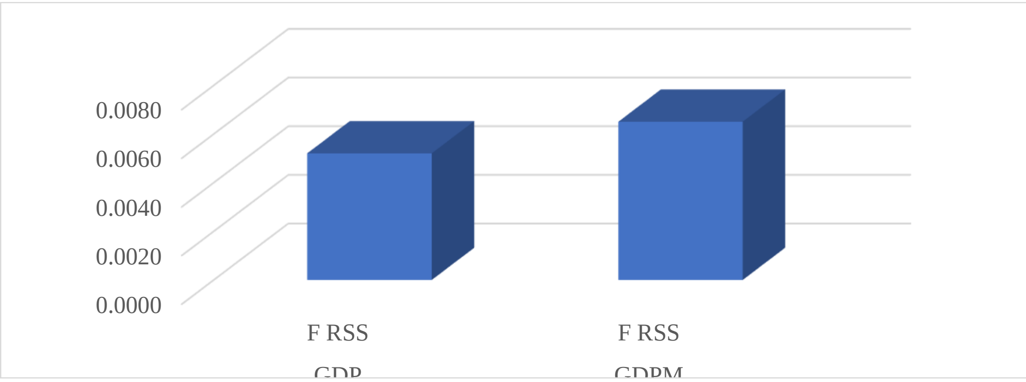

Fig. 4. Comparative analysis of fluctuations around the linear growth of India's GDP and GDP coming from manufacturing sector using F_{RSS} method

Source: Own calculation based on the RBI handbook statistics, 2023

3.3 Comparative Analysis of Fluctuations around the Linear Growth of India's GDP and Manufacturing Sector GDP Using Different Methods

In this section, we have tried to present year-to-year fluctuation using the adjusted Coppock method ($F'_{Coppock}$) for GDP and its one major good producing sector, which is manufacturing sector. We have found that the year-to-year fluctuation is higher in GDPM than GDP.

The comparative results for the overall fluctuation are presented in Fig. 4. The overall fluctuation of Gross Domestic Product is high in comparison to GDPM.

In Fig. 5, this research presents the results of a comparative analysis of fluctuation. Here we try to figure out average year-to-year fluctuation and average overall fluctuation for GDP and GDPM.

In GDPM, the $F'_{Coppock}$ index value (0.00151) is high in comparison to GDP. the result obtained from the CDVI index and RSS based method for GDP is less comparison to GDPM, and a high CDVI index value for GDPM indicates fluctuation creates mainly other types of fluctuation rather than year-to-year fluctuation though year to year fluctuation also high for GDPM in comparison to GDP as a whole. A low Coppock index value and a high F_{RSS} and the Cuddy and Della Valle values indicate the approximate average length of the full cycle for GDP is very high (68.21 years). Both values obtained from the $F'_{Coppock}$

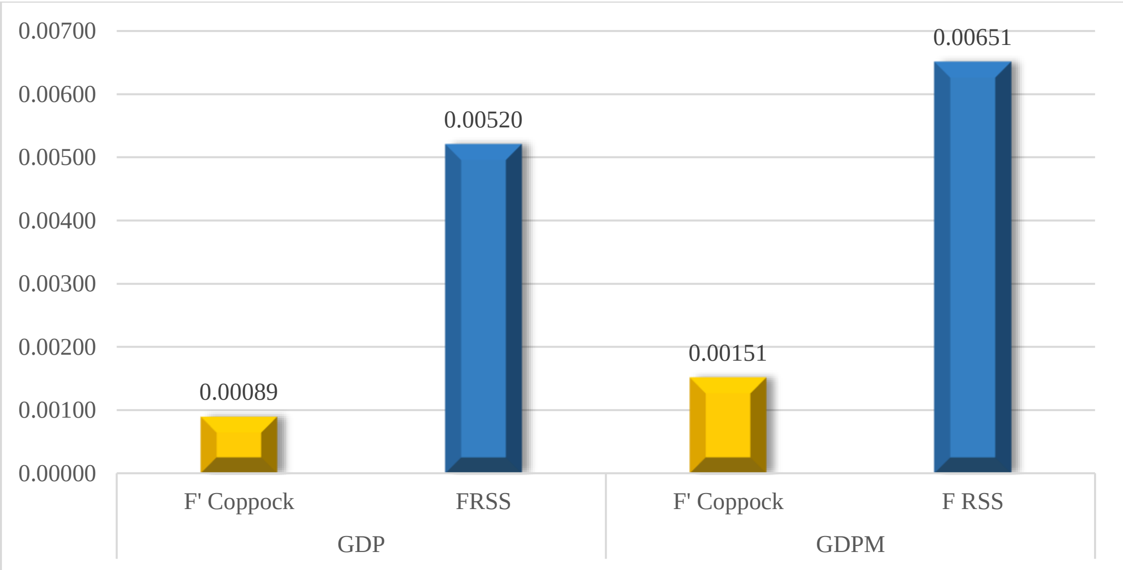

Fig. 5. Summary analysis of fluctuations around the linear growth of India's GDP and GDP coming from manufacturing sector using $F'_{Coppock}$ and F_{RSS} methods

Source: Own calculation based on the RBI handbook statistics, 2023

and RSS-based methods are relatively high in GDPM. However, due to a lower denominator compared to the numerator in calculating the average approximate length of a full business cycle, the length is shorter compared to GDP. The average approximate length of a full business cycle is 37.14 years. Based on GDP and manufacturing sector fluctuations, policy should focus on enhancing growth stability. This could involve implementing measures to control fluctuations, improving resilience against external shocks, and fostering sectoral diversification to reduce different types of fluctuations. The high average length of the full business cycle may indicate the possibility of structural breaks in the data set. Effective policies promoting stable growth in the manufacturing sector, supported by proper investments, may also shorten business cycle lengths, leading to stable, long-term economic stability.

4. CONCLUSION

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 (1978) 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. The RSS-based method and the Coppock-based method are not directly comparable, which is why Mondal and Mondal Saha (2008) have suggested an adjusted Coppock method that is comparable to the RSS-based method. Based on both year-to-year fluctuations and overall fluctuations, we have calculated the approximate length of the full business cycle of a data set.

Our study has examined the nature of fluctuations around the linear trend in India's gross domestic product (GDP) and its major good producing sector, namely manufacturing, for the period 1970–71 to 2019–20. For GDP and GDP coming from manufacturing sector, the amount of fluctuation is 0.96% and 0.93% of total variation, and 99.04% and 98.98% is explained by a linear trend (growth), respectively. The CDVI-based fluctuations for GDP and GDPM are 0.00526 and 0.0657, respectively. If we use R-square in place of adjusted R-square in the CDVI index, the result of the R-square-based CDVI is the same as the F_{RSS}-based measure of fluctuation. The year-to-year fluctuation is measured by the Coppock measure of fluctuation ($F_{Coppock}$), found to be 1.02716 and 1.04036 for India's GDP and GDP coming from manufacturing sector, respectively. The adjusted Coppock measure of average year-to-year fluctuation (Mondal and Mondal Saha (2008)) is comparable with the F_{RSS}-based measure of average overall fluctuation. The adjusted Coppock ($F'_{Coppock}$) measure of fluctuation is 0.00089 and 0.00151 for GDP and GDP coming from manufacturing sector, respectively. If these growth paths are extended, we get an approximate average length of the full business cycle for GDP, and GDP coming from the manufacturing sectors. The methodology for the approximate average length of the full business cycle (Mondal and Mondal Saha (2008)) gives us a full business cycle using information on overall and year-to-year fluctuation. In that case, it is 68.21 years and 37.14 years, respectively.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declares that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during the writing or editing of this manuscript.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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