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Growth of India's GDP during the Period 1970-71 to 2019-20- An Econometric Analysis

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ABSTRACT- This paper estimated the growth, endogenous break, and fluctuation in India's gross domestic product from 1970–71 to 2019–20. The linear growth estimation method is well established in the existing literature. The estimation of endogenous structural break and fluctuation measuring methods needs some modification and adjustment. The resulting estimates reveal that India's GDP consists of three breaks and four distinct phases in different policy regimes in the considered time interval, of which all four are full-length regimes, two upward spikes, one downward spike were created during the period. The highest growth rate was achieved at 6.54% from 2005-06 to 2019-20.

KEYWORDS: Growth, Endogenous Breaks, Fluctuation, Jel Classification: C18, O40

I. INTRODUCTION

India's Gross Domestic Product (GDP) is growing steadily in the post-independence era, although this rate differs across sectors and in different policy regimes. While assessing the country's economic situation, it is necessary to evaluate both the growth and cyclical nature of the fluctuation of GDP. Economic growth and fluctuations have an impact on a nation's economic performance, the betterment of which is an ultimate goal for human beings, societies, and nations. Growth in time series macroeconomic variables like GDP, sectoral GDP arises from the increasing use of human and physical capital, innovation, natural resources, etc. The growth of GDP may occur with the introduction of different government policies. The fluctuations around the trend linear growth path also arise in all these cases. There are different types of fluctuations that arise, like cyclical, year-to-year, and irregular ones. Fluctuating commodity prices, levels of financial development, trade liberalisation, reliance on agriculture, political stability, foreign resources, domestic shocks, natural disasters, climate conditions, and other types of economic and non-economic factors create different types of fluctuation. Structural breaks occur due to sudden policy changes by the government or policies prescribed to accelerate a structural shift towards a sustainable economic future. The present work considers the fifty-year time period from 1970–71 to 2019–20 to analyse the trend growth in India's GDP, breaks, and fluctuations. Breaks identified through a properly designed methodology are justified by historical data on policy changes, natural calamities, or other unforeseen events. This is expected to have immense policy implications.

II. LITERATURE REVIEW

Brown, et al.[7] have used recursive residuals to test for structural change over time. Nelson, Plosser [12] argued that most macroeconomic time series are difference-stationary rather than trend-stationary processes. Zivot and Andrews [1] and Perron [13] tests captured only one (the most significant) structural break in each variable with endogenous procedure. Lumsdaine and Papell [11] extended the methodology of Zivot, Andrews [17] to developed a test that allows for two endogenous structural breaks. Bai-Perron [3] allowed inference to be made about the presence of structural change and the number of breaks. Balakrishnan and Parameswaran [5] have estimated multiple structural breaks in time series econometric variables for 10 OECD countries using Bai and Perron [3] [4] and Perron and Zhu [14] methods. Dholakia and Sapre [10] have founded detection of break dates is sensitive to base year changes, marginal extension of time series. Roy-Choudhury, Chatterjee (2014) have used Bai and Perron [3] [4] and Boyce[6] method and further to the consideration of three possible breaks in the series. To estimate fluctuation around the linear growth path, Cuddy-Della Valle[9] suggested an overall fluctuation measuring method on the basis of the de-trend of the coefficient of variation. Coppock's [8] also suggested a measure of fluctuations in a linear growth path, but this method is different from Cuddy-Della Valle's [9] because this method is based on year-to-year fluctuation. Anjum and Madhulika [2] have tried to find agricultural fluctuation in India using both the Cuddy-Della Valle [9] method and Coppock's [8] method.

III. OBJECTIVE

The main objective of this paper is to find the linear growth, multiple structural breaks and fluctuations of India's gross domestic product.

During the past 50 years (from 1970–71 to 2019–20), India's GDP have grown steadily. GDP growth is a key pillar of an economy. Proper growth, breaks and fluctuations measures assist policymakers in formulating future policy recommendations.

IV. DATABASE AND METHODOLOGY

The data on India's GDP is taken from a secondary source, the RBI Handbook of Statistics, 2023. The data convert into 2011-12 base year constant price. The data measured in rupee in crore.

To measure of linear growth, we have used semilog-linear trend regression given by,

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

Where, 'e_t' is the random error term, 't' stands for time, 'b' stands for the constant rate of exponential growth, 'Y_t' is the dependent variable and 'ln' stands for natural logarithm. This method also used by (Pradhan and Mondal[15]

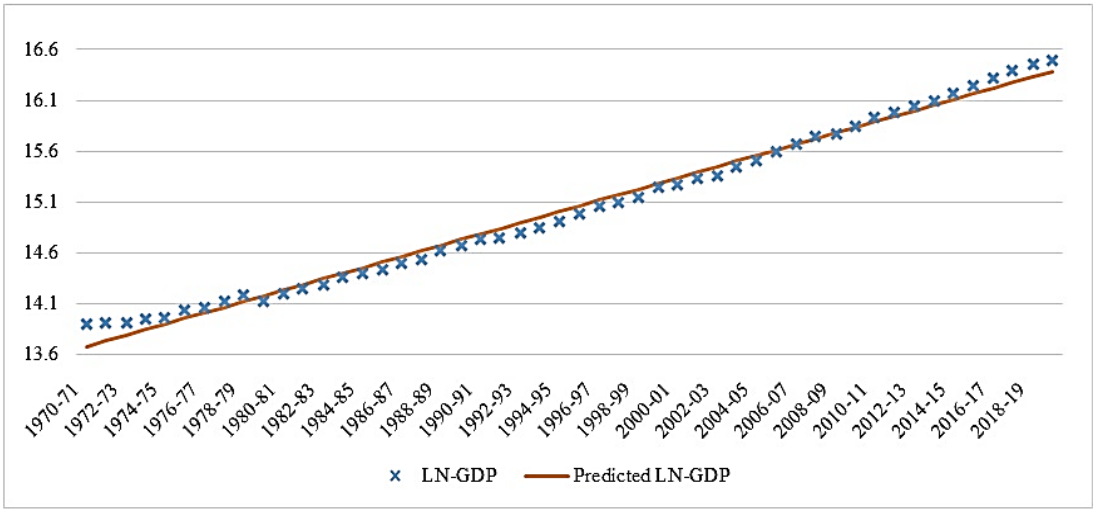
The analysis of fluctuations around the linear trend line and overall fluctuation from the logarithmic trend is considered by the residual sum square (RSS)-based method of fluctuation, which can be written as $F_{RSS}= \sqrt{\frac{1}{T}\sum_{t=1}^{T} {e_t}^2}/\overline{ln\, Y_t}$. Coppock [8] measure of the fluctuation index is given by $F_{Coppock} = Exp\ (S.D.(ln(\frac{Y_{t+1}}{Y_t})))$ is used to gauge year-to-year fluctuation. As said in the literature review section, both the Cuddy-Della Valle [9] method and Coppock's [8] method give different views of measuring fluctuation around the linear trend line. Again, the Cuddy-Della Valle [9] method and the RSS-based method give the same overall fluctuation measuring method, but the only difference is that the Cuddy-Della Valle[9] method uses the adjusted R square in its calculation, whereas the RSS-based method uses the R square to estimate fluctuation around the linear trend growth path. Another problem arises in the Coppock-based method, which has a lower limit of 1 but no upper limit, whereas the RSS-based method also has a lower limit of 0 and here also no upper limit. The RSS method gives overall fluctuation like the Cuddy-Della Valle[9] method, and it takes into consideration both year-to-year fluctuation, which is given by Coppock's [8], and an overall long cycle, which arises due to a business cycle or a break in the growth path.

For comparing these two views of fluctuation given by these two measures, Coppock's measure is modified to have $F'_{Coppock}$. The adjusted Coppock measure of fluctuation is written as $F'_{Coppock} = (SD(ln(\frac{Y_{t+1}}{Y_t})))/(2(\overline{ln\, Y_t}))$. From these two measures the average length of an entire cycle can be estimated by, $2(F_{RSS}/F'_{Coppock})^2$ [Mondal and Mondal Saha[16], Pradhan and Mondal[15] . A stationary test is necessary for the break estimation in a time series analysis. We have used Augmented Dicky Fuller (ADF) test to test of stationarity on data. In the existing literature, the standard procedure of break estimation technique has prescribed by Bai and Perron[3] [4], created discontinuity each and every break point with taken minimum Schwarz information criterion (SIC) test criteria. Boyce's methodology [6] has created an algorithm to join a successive regime arises kink with no discontinuity.

For the estimation of multiple structural breaks in a linear growth path, we use the Bai and Perron [3] [4] method of multiple structural breaks and the Boyce [6] kink method with some modifications. The Bai and Perron [3] [4] method of multiple structural breaks suggested that there is just a one-year subperiod between two growth regimes, but our suggested point is that either two growth paths create just slope change or there is a there is a one- or two-year subperiod between two growth paths, basically a 0-1-2-year subperiod between two growth paths. It may be possible that one or two years of growth downfall and the next one or two years revive it, or vice versa. If only there is a there is a slope change between two growth paths, we can say Boyce's kink method is used for the estimation of that break. If one or two-year growth declines and the next one or two years revive, or say, a V-shape of downward spike for that model, we can say double kink growth model with downward spike. If one or two years of growth go upward and the next one or two years go down, or say, inverted V shape of upward spike for that model, we can also say double kink growth model but upward spike. In our novelty, we also considered truncated regimes at two ends because we cannot say the nature of the data before estimation, so it is possible that we may not consider a full-length growth regime at two ends, which is why we considered truncated regimes. All of these possibilities are incorporated into our further modified Bai and Perron [3][4]method using an algorithm in the FORTRAN program language.

V. RESULTS AND FINDINGS

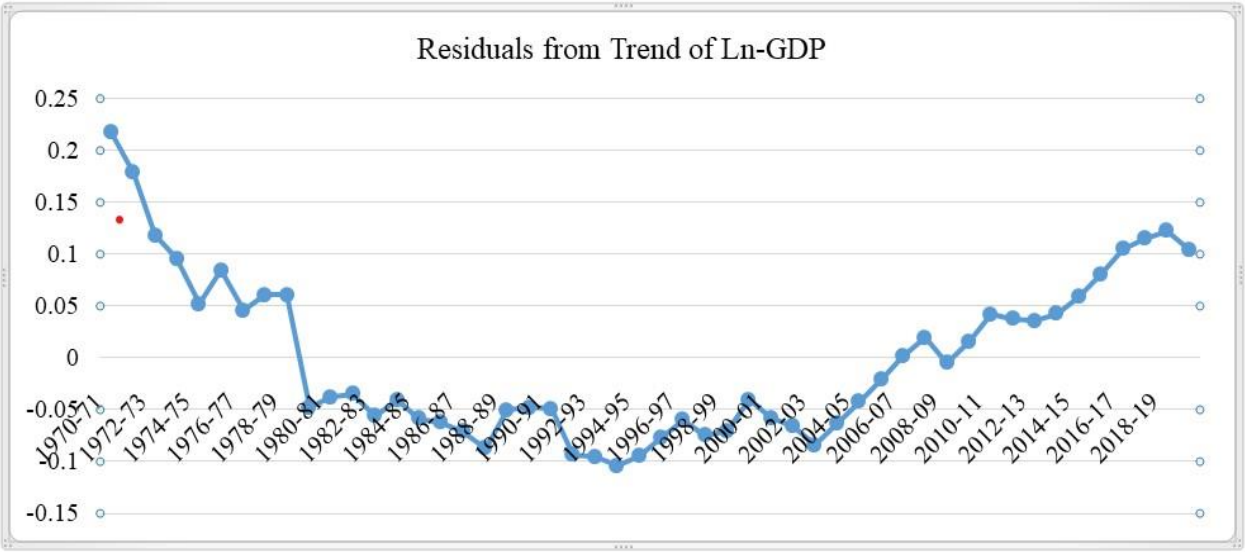
In the result and discussion section, we have presented the linear growth, multiple structural breaks, and fluctuation of India's gross domestic product from the period of 1970–71 to 2019–20.



Source: author's own calculation based on RBI handbook statistics, 2023

Figure 1: Linear growth of India's GDP during the time period 1970-71 to 2019-2020

The data points of Ln-GDP indicated there are wide verity around the linear trend line. The wide variation of data points indicates there are may have some fluctuations around the trend linear growthy path.



Source: author's own calculation based on RBI handbook statistics, 2023

Figure 2: Fluctuation around the trend line of India's GDP during the time period 1970-71 to 2019-2020

Table 1: Result for Ln (GDP) regress on Time along with fluctuations around trend line

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)

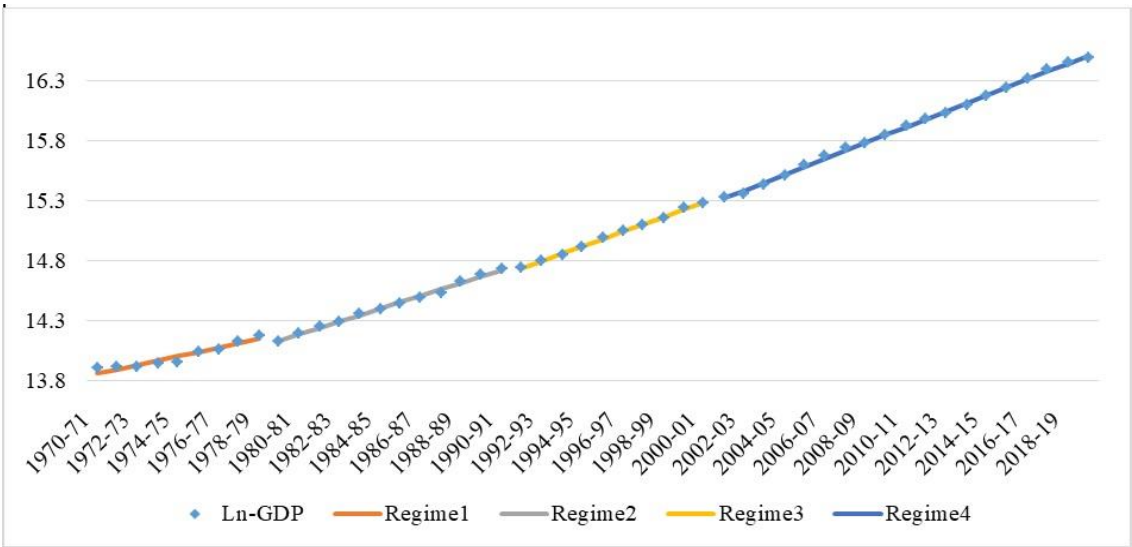
Source: author's own calculation based on RBI handbook statistics, 2023

In Figure1 and 2, the log (natural) value of India's GDP for the period 1970-71 to 2019-20 is presented in the figure. The data on India's GDP is obtained from RBI handbook of statistics. According to the data unveiled in Table 1, the annual average growth rate is identified as 5.52% per year. The statistical analysis reveals that the R-square =0.9904, Adjusted R-square = 0.9902, F-value = 4969.75 with P-value = 4E-50. The overall of fluctuation, as presented by the R-square, is 0.96% of the total variation (as 1 – R-square = 0.0096). The data point representing the natural logarithm of gross domestic product in Figure 1 shows a pattern of fluctuation within the referred period of the date set. Trend analysis of India's GDP (Figure 1) showed a positive growth rate throughout the period from 1970-71 to 2019-20. On the basis of graphical illustration, we find a linear upward trend with numbers of fluctuations (ups and downs) in the log values of gross domestic product, as presented by the linear straight line indicating constant growth. Figure 1 clearly indicates there are fluctuations in the data set, so we have to find breaks in the growth path and also fluctuations around the linear growth path.

The RSS-based measure of fluctuation, given the overall fluctuation around the trend based on the mean of Ln-GDP, has a value of the RSS-based measure of fluctuation of India's GDP is 0.00520, which is slightly different from the Cuddy and Della Valle [9] based measure of fluctuation of India's GDP. The Cuddy and Della Valle [9] proposed measure of fluctuation is CV× (1-$\bar{R}^2$)). The Cuddy and Della Valle (CDVI) [9] measure of fluctuation in India's GDP is 0.00526, indicating overall average fluctuation from the mean Ln-GDP of the detrending dataset. The year-to-year measure of fluctuation is given by Coppock (1962). The Coppock (1962)-based measure of fluctuation is 1.02716. RSS-based and Coppock-based measures are not directly comparable as both have different notions of principle, so the adjusted Coppock (F'_{Coppock}) measure of fluctuation of India's GDP is 0.00089, a small amount compared to the RSS-based measure of fluctuation. In other words, we say that the year-to-year average fluctuation from mean Ln-GDP is very low in comparison to the overall average fluctuation of Ln-GDP. 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 Figure 2. The average length of the full cycle indicates that the role of structural breaks in growth path cannot be ignored. This seems to differ slightly from the RSS-based measure of fluctuation, indicating year-to-year fluctuation present in the growth path.

Before estimating structural breaks in a very long-term time series variable (preferably more than 50 years), it is important to test whether the data have a unit root or not.

For estimating the unit root test, we use the most popular method, which is the Augmented Dickey-Fuller (ADF) test. The result of the ADF test shows that the fifty-year-long time series is stationary at the first difference with a 1% level of significance. For the estimation of endogenous break, we have used the Bai and Perron method and our proposed further modified Bai and Perron method, and we have also tried to compare both methods. For the estimation of breaks in the growth path using the Bai and Perron method, we are using the FORTRAN algorithm for detailed outcomes for break analysis. We have used the simultaneous method rather than the sequential method.



Source: Author's own calculation

Figure 3: Discontinuous path of India's GDP during the period 1970-71 to 2019-20 obtained from Bai-Perron's methodology of structural breaks

In figure 3, we have presented the endogenous break nature of India's gross domestic product using the Bai and Perron structural break estimation methods. We have found there are three breaks and four regimes throughout our referred period.

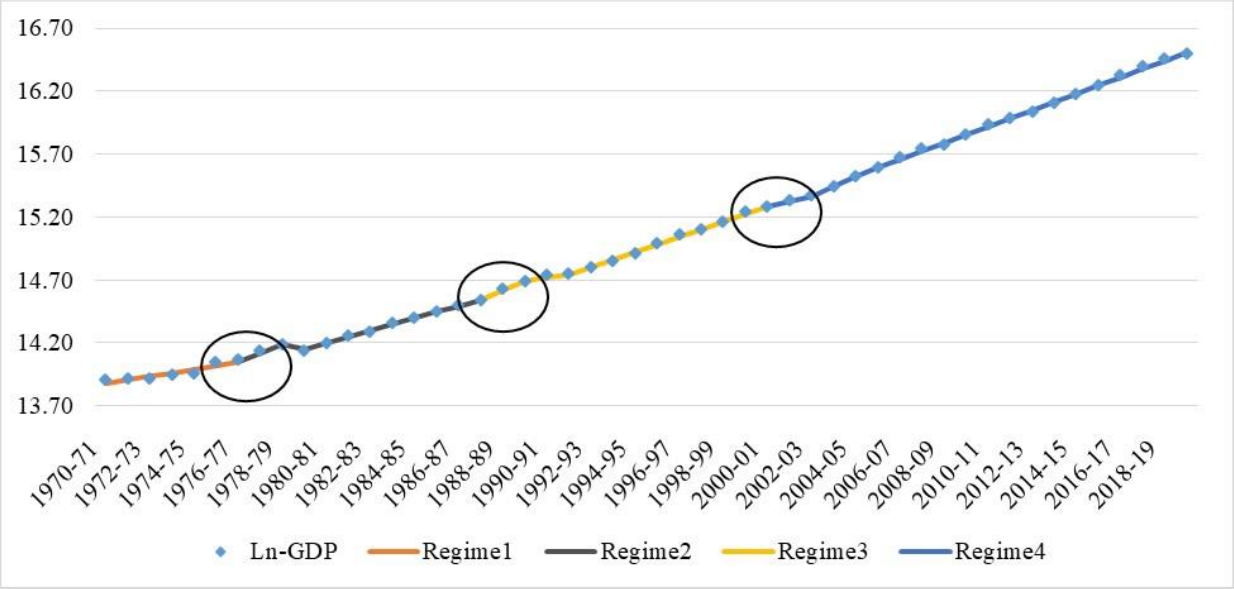
Table 2: Growth rates and corresponding P values of different regimes are obtained from Bai and Perron's methodology of structural break estimation

Endogenous break in GDP using Bai and Perron method			
SIC			**-7.3257**
SIC adjusted with No of Coefs.			**-7.5604**
R Square			0.9996
Adjusted R Square			0.9995
Standard Error			0.0182
F			13784.83
Significance F			1.9E-68
	Coeffi.	*P-value*	*Year (Duration)*
Intercept	13.8244	2.3E-94	
Regime1	0.0362	6.9E-19	1970-71 to 1978-79 (9)
Break 1	-0.0153	3.1E-01	1979-80
Regime2	0.0536	8.5E-33	1980-81 to 1990-91 (11)
Break 2	0.0147	3.2E-01	1991-92
Regime3	0.0610	3.1E-30	1992-93 to 2000-01 9)
Break 3	0.0339	1.5E-02	2001-02
Regime4	0.0661	5.4E-49	2002-03 to 2019-20 (18)

Source: Author's own calculation

In figure 3 and table 3 we have shown multiple structural breaks in the linear growth path of India's GDP using the Bai-Perron method with growth rate and corresponding p-values of each regime. Optimum break points have selected by the minimum SIC value. India's GDP is shown three breaks throughout the period between 1970-71 to 2019-20. The problem with the Bai and Perron method is that the growth path becomes discontinuous at a break point. The one-year discontinuous break estimation method may not address the true nature of breaks in a time series data set. This may be a misleading estimate. A single, double, and/or triple kink may be present in a

growth path. There may be either a zero or one or two-year subperiod between the two regimes, and for an upward or downward spike, there may be either a one- or two-year subperiod for ups and either one or two years for downs, or vice versa. We have tried to accommodate these types opossibilities in the Bai-Perron method with the help of Boyce's kink methodology. Two regimes on two edges may not achieve the length of an entire regime because the period that a researcher considers depends entirely on it. We have tried to establish further modified Bai Perron method (FMBP).



Source: author's own calculation

Figure 4: The growth path of India's GDP by applying FMBP technique

In Figure 4, we have presented the results of multiple structural breaks using the further modified Bai and Perron method. The figure very nicely presents an upward spike and a downward spike, which are not addressed using the Bai and Perron method.

Table 3: Different growth regimes and sub-periods in India's GDP growth path by applying the FMBP method

Endogenous break in GDP using FMBP method					
SIC				-7.8307	
R-square				0.99974	
Adjusted R Square				0.99967	
F				14848.7	
Sig.F				1.50E-66	
			Coeffi.	*P-value*	*Year (Duration)*
		Intercept	13.8499	1.2E-89	
Regime1		H1	0.0282	6.6E-13	1970-71 to 1976-77 (7)
Upward spike	Break 1	H2	0.0718	4.6E-10	1977-78 to 1978-79
	Break 1	H3	-0.0459	6.7E-03	1979-80
Regime2		H4	0.0501	6.0E-27	1980-81 to 1987-88 (8)
Upward spike	Break 2	H5	0.0747	1.1E-11	1988-89 to 1989-90
	Break 2	H6	0.0232	4.8E-03	1990-91 to 1991-92
Regime3		H7	0.0605	5.5E-33	1992-93 to 2000-01 (9)
Downward Spike	Break 3	H8	0.0385	1.3E-05	2001-02 to 2002-03
	Break 3	H9	0.0816	7.7E-14	2003-04 to 2004-05
Regime4		H10	0.0654	1.4E-45	2005-06 to 2019-20 (15)

Source: author's own calculation

In Table 4, we have shown the results of multiple structural breaks using the further modified Bai-Perron method (FMBP). There is no need to pre-fix break points exogenously in the FMBP model. The FMBP model detects break points on the basis of the minimum SIC value endogenously using the FORTRAN algorithm. In our model, we set a pre-fixed minimum length for full-length regimes as well as two ends for truncated regimes, which are 7 years for full-length regimes and 4 years for truncated regimes. The reason behind the 7-year full-length regime is that some economists suggest a 5-year minimum-length regime, but some other economists suggest that a 5-year

minimum-length regime is too small, and the 10-year minimum-length regime is too large, so we considered in between that 7-year full-length regime. The results of multiple break points are presented in Table 4, where we have tried to present very nicely all growth regimes, subperiods, and growth rates of all full-length regimes as well as all subperiods, along with the corresponding p value of each period. The results of all p values indicate that all full-length regimes are statistically significant at less than 1% level of significance. The H1, H4, H7, and H10 indicate the full-length growth regimes. There are four full length regimes, not any truncated regimes, two upward spikes, and one downward spike created during the time period. For the period 1970–71 to 1976–77, the growth rate was 2.82%. The following two years achieved a high growth rate of 7.18%, which was continued from 1977–78 to 1978–79. The most important and problematic fact about the Indian economy is that GDP declined to -4.59% in 1979–80 due to contractions in agricultural and industrial production. The highest growth rate was achieved at 6.54% from 2005–06 to 2019–20. In between H1 and H4, H4 and H7 created a downward spike, and in between H7 and H10, they created an upward spike. The expected slowdown in GDP growth for two years (2001–02 to 2002–03) is mainly because of a sharp fall in agricultural GDP due to droughts.

VI. CONCLUSION

India's GDP has grown significantly, at 5.52% per annum, for the last fifty years, from 1970–71 to 2019–20. Fluctuations around the linear trend line explain a very small part of the overall variability. The fifty-year time period consists of three structural breaks, which indicate four separate regimes. Every regime is full-length. There are no truncated regimes in the data set, but it may be possible in some other data set to arise truncated regimes at two ends. Two upward spikes and one downward spike were created during the time period. These downward spikes, upward spike not taken Bai-Perron methodology causes breakpoint not properly estimated. The highest growth rate was achieved at 6.54% from 2005-06 to 2019-20. FRSS based fluctuation for GDP is to be 0.00520, which is slightly less than F'Coppock (0.00089) calculated earlier. The average length of the full cycle for GDP is 68.21 years.

CONFLICTS OF INTEREST

The authors declare that they have no conflicts of interest between them and with any third party.

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