International Journal of Innovative Research in Engineering and Management (IJIREM)
ISSN (Online): 2350-0557, Volume-11, Issue-6, December 2024
https://doi.org/10.55524/ijirem.2024.11.6.1
Article ID IJIR3036, Pages 1-7
www.ijirem.org

Fifty Years of India's Manufacturing Sector Growth Journey- An Endogenous Break Perspective

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

Received: 24 October 2024 Revised: 8 November 2024 Accepted: 23 November 2024

ABSTRACT- The manufacturing sector, together with its interconnected relationships, both forward as well as backward linkage, has significant potential for generating employment and plays an important factor in a country's growth and prosperity. With the development of machines and new manufacturing processes, goods could be produced more quickly and at a lower cost. Consequently, the expansion of the manufacturing sector took place, resulting in the generation of employment opportunities and a notable increase in output levels. In the last fifty year from 1970-71 to 2019-20 total four breaks in the manufacturing sector growth path. This study investigates structural breaks in India's manufacturing sector output growth (1970–71 to 2019–20), which grew at an average annual rate of 6.08%. Using Boyce's [4] kink method, Bai and Perron's [2] [3] approach, and the novel Further Modified Bai and Perron (FMBP) method, structural breaks were estimated endogenously via a FORTRAN algorithm. The FMBP method improves upon existing models by incorporating kinks, one- or two-year subperiods, V-shaped breaks, and truncated regimes with a minimum length of seven years (four for truncated regimes). Findings reveal five distinct growth regimes, including one truncated regime, offering a comprehensive analysis of growth dynamics and methodological advancements.

KEYWORDS- Growth, Endogenous Breaks, Manufacturing Sector

JEL CLASSIFICATION- C18, O40

I. INTRODUCTION

The beginnings of the Industrial Revolution promoted the emergence of modern transportation technologies, like railroads and steamships, therefore expediting the transfer of commodities across long distances. India has attained a commendable level of self-reliance in the manufacturing sector of many essential and capital goods since independence. The potential for growth in the manufacturing sector has the ability to bring a significant portion of the Indian population out of poverty by redirecting a majority of the workforce away from low-paying agriculture-related jobs. The development of the manufacturing sector will contribute to a more stable and well-off India, thereby attracting more economic opportunities. These developments led to the growth of trade and globalization as countries began to produce specialized goods that they could produce more efficiently and trade with other countries.

In the field of time series econometrics, the term "structural break" refers to a notable and sudden change in the fundamental structure or dynamics of a specific set of time series data. Structural breaks may arise due to a multitude of factors, including alterations in economic policy, external disturbances, developments in technology, or other fundamental changes in the method by which data is generated. The identification and consideration of structural breaks are of utmost significance as they possess the potential to significantly influence the interpretation and prediction of time series data. The process of identifying structural breaks incorporates the detection of certain time points at which noticeable shifts or changes in the statistical characteristics of the time series data are seen. Various techniques are often used to identify structural breaks, including visual inspection of plots, statistical hypothesis testing, and model-driven methodologies.

II. REVIEW OF LITERATURE

The literature on structural change in time series economics has been enriched a lot in the last 20 years of the 20th century and in the first 20 years of the present century. Some important theoretical and empirical works on structural breaks in time series include Perron [6], Zivot & Andrews[10], Andrews [1], Bai & Perron [2][3] among others. Boyce [4] gives a method for continuous growth path on different slopes, basically kink growth path. Undoubtedly the pioneering work in this field is done by Perron [6] and Bai & Perron [2][3]. Dholakia & Sapre [5] have observed that break dates are sensitive to the changes of the base year, which is the marginal extension in the existing literature for time series econometrics.

In the present work, we consider the period from 1970–71 to 2019–20 to analyse the nature of structural changes or breaks in the linear growth path in India's GDP as a whole and major sector of GDP, namely the manufacturing sector. Breaks identified through Boyce [4], Bai & Perron's [2], [3], and the proposed further modified Bai & Perron (FMBP) methodology can be justified by historical data on policy changes, natural calamities, or other unforeseen events, all of which are expected to have immense policy implications.

III. OBJECTIVES

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

The primary objective of this chapter is to examine the average annual growth of India's manufacturing sector output.

To explain different types of structural break estimation methods and determine the optimum structural breaks of India's GDPM.

We are utilising existing methods and developing a new approach based on the gaps in the literature review section to estimate the breaks in the linear growth path.

IV. DATABASE

The data on India's GDPM 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.

V. METHODOLOGY

The concept of economic growth is a central theme in modern economics. The significance of economic growth cannot be overstated in the context of social prosperity, as it facilitates job creation, market expansion, and the enhancement of living standards. Measuring economic growth is, therefore, of great importance for policymakers, economists, and society as a whole.

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

$ln\,Y_t = a + bt + et \;\; \dots \;\; \dots \;\; \dots$ (1)

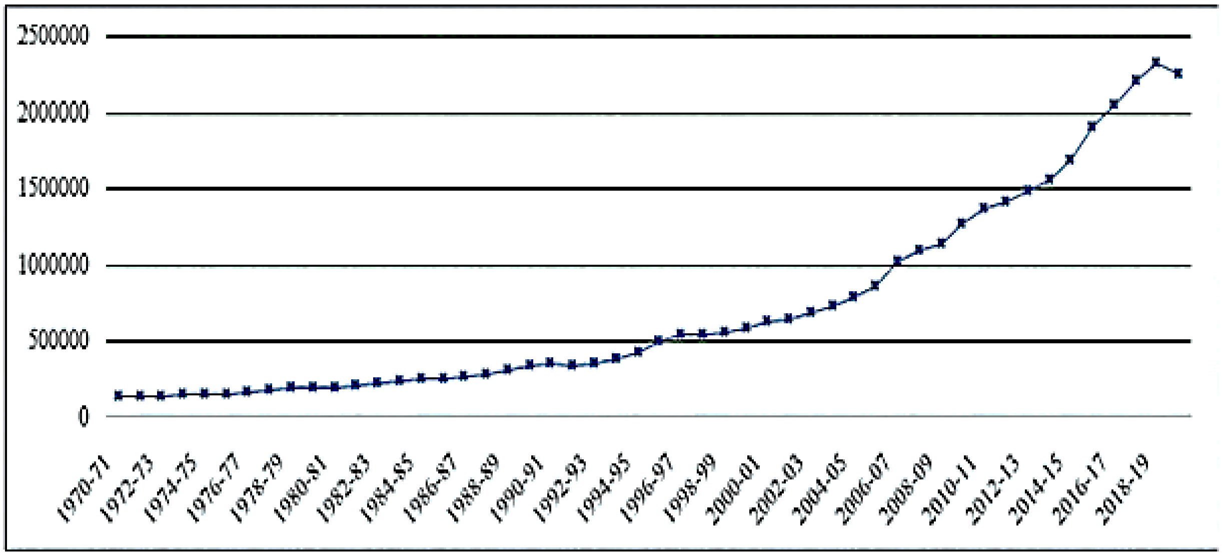
In order to figure out the functioning of the model, it is necessary to separate out the constituent elements of the equation. The dependent variable in the model is expressed as the natural logarithm of 'Y_t', which is denoted as '$\ln(Y_t)$', while 't' is the independent variable representing time. 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'. This method also used by (Pradhan and Mondal [8] and Pradhan and Mondal [9]). 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.

The methodology for estimation of multiple structural breaks given by Perron[6], Bai and Perron [2][3], Perron and Zhu[7], and some other econometricians estimate the m parameter for m+1 regimes. They treat them all as unknown break dates and aim to identify a break point from within the data set. The Schwarz Information Criterion (SIC) is a superior measure for optimal break date selection to any other information criteria among a finite set of methods. So, no doubt, this method is a standard procedure for optimum break point selection with a fixed minimum length of regime. The Bai and Perron endogenous break estimation method gives a discontinuity in the growth path at each and every break point. Basically, one regime ends with the k^{th} year, and the next regime starts in the $k+1^{th}$ year. So, in a discontinuous growth path, every regime may not be comparable for a significant difference in the growth rate of each regime or not. Boyce [4] has used an algorithm to estimate the growth path with kink at a break point. He gives a continuous growth path with just a slope change, or, say, kink growth path. So, neither method may give a proper explanation of the growth path; it may be better if we use a one-year subperiod between regimes (Bai and Perron, [2][3] with a continuous kink growth path [4] or we can say a double kink growth path. We are trying to incorporate another possibility, suppose that for the manufacturing sector, one year creates shocks and in the following year revives them and the continued growth rate continues to maintain the previous rate, or vice versa. This type of break we can call V-shaped or inverse V-shaped breaks between two regimes, or using Boyce's method, we can say a triple kink model, an upward spike, or a downward spike. With the help of the Bai and Perron method, we try to incorporate all of these possibilities, such as kink in between two regimes, a one-year subperiod between two regimes, double kink, or a spike (V-shape) between regimes. The Bai and Perron method of structural break estimation considers a one-year subperiod; we consider it to be one or two years, and for a spike, we also consider one or two years of downfall, followed by one or two years of revival, or vice versa. All types of possibilities may occur in the same time series data or may not be present in all cases in a single data series. At the two-end regime of time series data, researchers may not consider the entire regime; they may incorporate a truncated regime at the two ends, which is solely dependent on them. We incorporate a truncated regime at the two ends, which is also another modification to our methodology. We incorporate a seven-year full-length regime and a truncated regime for four years. After all modifications, we set up the Further Modified Bai and Perron Method (FMBP) to estimate structural breaks in India's GDPM. For the estimation of FMBP, we designed a set of algorithms in the FORTRAN programming language.

VI. RESULTS AND FINDINGS

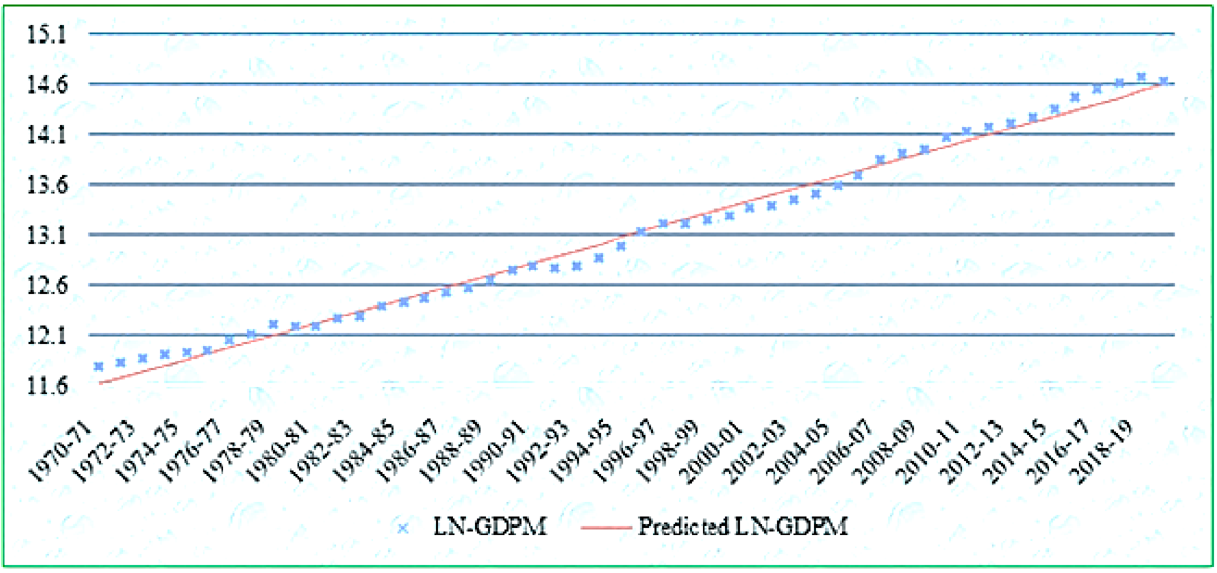
In this section, we have tried to discuss the trend growth nature of India's GDP coming from the manufacturing sector. Before finding the trend growth of manufacturing sector output, first, we plot the data points to find the nature of the data series (Figure 1). We have found that the output of GDP accruing from the manufacturing sector is exponential in nature. So, the log values of India's manufacturing sector GDP are now regressed on time (t) to estimate the annual average growth rate for the linear trend line.



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

Figure 1: The exponential growth trajectory of India's GDP coming from manufacturing sector from 1970-71 to 2019-20

The study evaluates the trajectory of India's GDP accruing from the manufacturing sector throughout the time period from 1970-71 to 2019-20. The statistical results of this analysis are displayed in Table 1. Figure 2 presents the linear trend growth of India's manufacturing sector (GDPM) with in-GDPM data points.



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

Figure 2: Data points (log values) of India's GDPM and their linear trend: 1970-71 to 2019-20

The analysis demonstrates a clear pattern in India's GDP taken from the manufacturing sector (GDPM). The data shows a nearly linear trend when evaluating the logarithmic value of India's manufacturing sector output. This is evident from the presence of a solid straight line, which indicates an upward trend. The growth rate of India's manufacturing sector output is estimated at 6.08% per annum, R-square =0.9907, Adjusted R-square = 0.9905, F-value = 5089.60 with P-value = 2.25E-50.

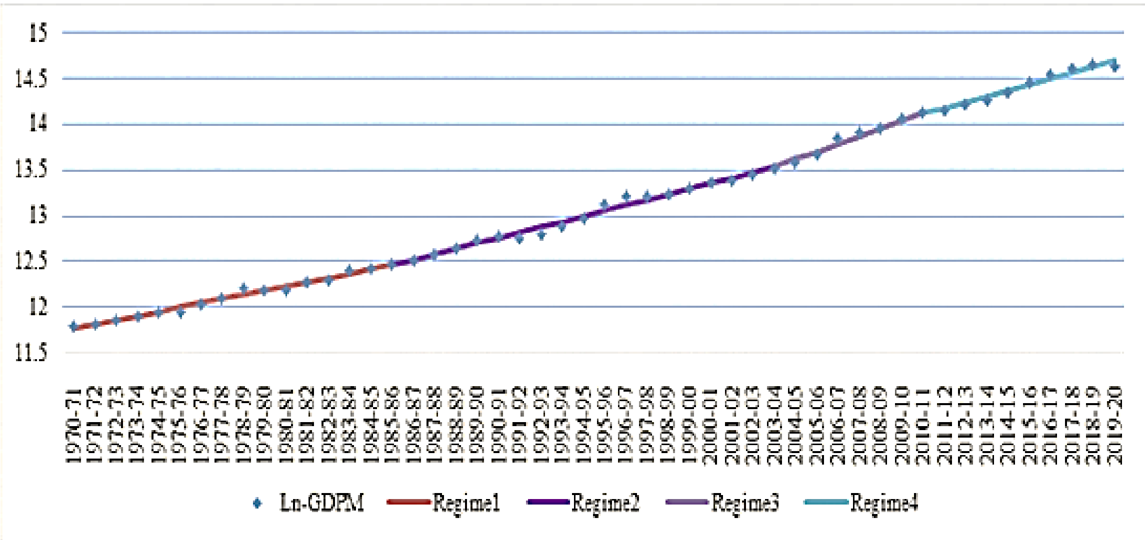
The estimated equation we can write as: ln(GDPM) = 11.5524+ 0.0608t, …(8).

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

	Coefficients	R Square	0.9907
Intercept	11.5524	Adjusted R Square	0.9905
Time (T)	0.0608	Standard Error	0.0870
F value	5089.6	Significance F	2.25E-50

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

The manufacturing sector in any country plays a key role in economic development in any developing country like India. To find out breaks in linear growth path of manufacturing sector also an important factor. Although in this present paper, the breaks are identified endogenously using the FORTRAN programming language, we also check in 1991, India adopted the famous LPG model, which is liberalisation, privatisation, and globalisation. We know that there is an exogenous event until we adopt an endogenous method to identify the breaks and try to check if any significant breaks occurred in that period or not. We also check whether that has an effect on structural breaks in the growth path or not, and we also check for any other breaks. Finally, we have to check some reasons for the break based on historical events.



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

Figure 3: The Kink Growth Path of India's GDP Coming from the Manufacturing Sector Using Boyce's Method

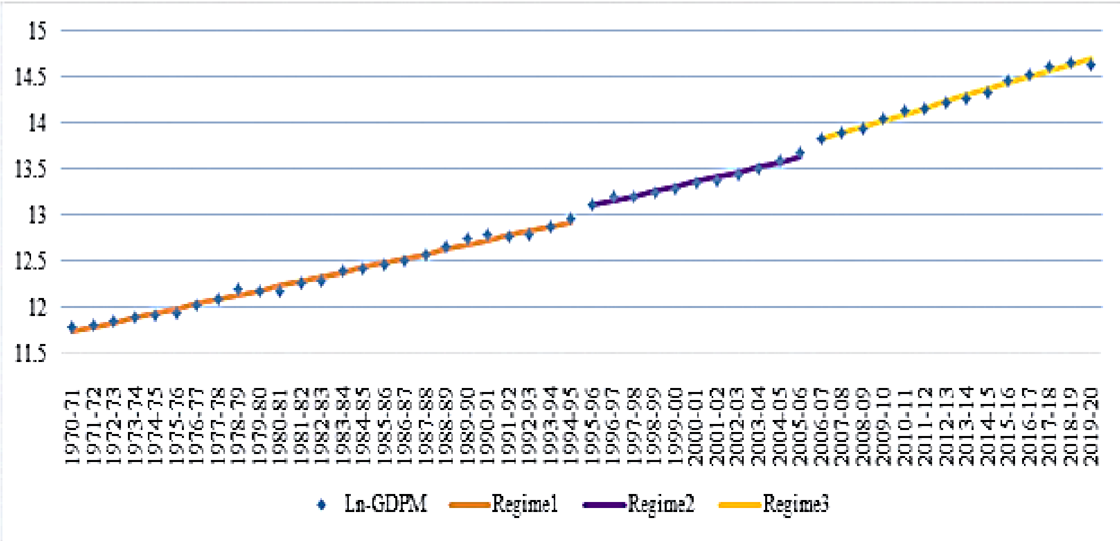
Figure 3 and Table 2 show there are three breaks, or four regimes, in India's GDP that come from the manufacturing sector's growth path using Boyce's kink method. The optimum SIC value is -6.2250, and all coefficients of growth paths are significant. The highest growth rate achieved in the third regime was 8.37% in the years 2004–05 to 2010–11. We have called this period India's golden age. The results are quite interesting; there are no breaks found near 1991, but there may be breaks created near 1991. There may be a crash or leap forward, so we need Bai and Perron's methods to find such possibilities. A crash or leap-forward does not identify Boyce's method, which is the main fault of Boyce's methods, which only identified kink types of breaks.

Table 2: The results of the kink growth path of India's GDP coming from the manufacturing sector using Boyce's method

SIC			**-6.2250**
R Square			0.9983
Adjusted R Square			0.9981
Standard Error			0.0386
F			6528.5
Significance F			1.5E-61
	Coeffi.	P-value	Year (Duration)
Intercept	11.7184	4.3E-90	
Regime 1	0.0461	7.0E-30	1970-71 to 1985-86 (16)
Regime 2	0.0597	2.7E-40	1986-87 to 2003-04 (18)
Regime 3	0.0837	9.0E-27	2004-05 to 2010-11 (7)
Regime 4	0.0637	1.2E-21	2011-12 to 2019-20 (9)

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

The results of multiple structural breaks using the Bai and Perron methodology are presented in Figure 4. The presented diagram demonstrates the presence of three different regimes or breakpoints within the growth path. There exist two distinct breaks, each of which creates a significant leap forward. Table 3 shows the optimum SIC value is -6.4721 with adjusted coefficient for SIC estimation, which is lower than the results obtained from Boyce's kink method. Here we also incorporate another problem.



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

Figure 4: Breaks in the linear growth path of India's GDP coming from the manufacturing sector using the Bai and Perron method

Bai and Perron [2][3] considered three dummies for each break: slope change, break change, and intercept change. However, only the slope change and intercept change dummies are sufficient to calculate the optimal break points. Including additional dummies or coefficients can lead to a misleading calculation of the Schwarz Information Criterion (SIC). In this study, we demonstrate that even with the same break points, two different SIC values can be obtained. The first SIC value is as provided by Bai and Perron and implemented in sophisticated software like EViews. The second SIC value, adjusted for the number of coefficients, represents our proposed new SIC value, which considers only two dummies for each break. So, we can conclude that a one-year break between regimes gives better results than the kink method. All the coefficients of regimes and breaks have significance. Here, the first regime creates 4.92% for 25 years in the periods 1970–71 to 1994-95. There were two upward jumps at 18.03% and 20.95% in the years 1995-96 and 2006–07, respectively. The highest growth rate was achieved from 2007-08 to 2019-20 at 6.63%.

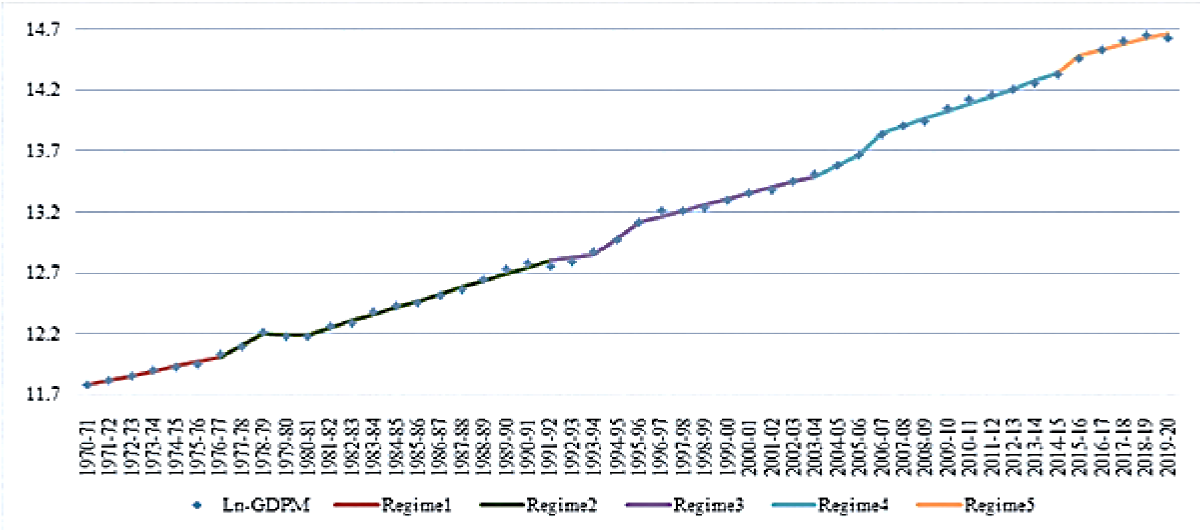
Table 3: Results of breaks in the linear growth path of India's GDP coming from the manufacturing sector using the Bai and Perron method

SIC			**-6.3157**
SIC adjusted with No of Coeffs.			**-6.4721**
R Square			0.9988
Adjusted R Square			0.9986
Standard Error			0.0331
F			7074.0
Significance F			1.0E-62
	Coeffi.	P-value	Year (Duration)
Intercept	11.6975	1.6E-94	
Regime 1	0.0492	1.1E-41	1970-71 to 1994-95 (25)
Break 1	0.1803	4.8E-10	1995-96
Regime 2	0.0519	2.1E-20	1996-97 to 2005-06 (10)
Break 2	0.2095	1.3E-10	2006-07
Regime 3	0.0663	4.8E-31	2007-08 to 2019-20 (13)

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

The problem with these results is that there may be an upward spike or a downward spike, which indicates there may be one or two years of downfall growth and the next one or two years revive it, or vice versa. The optimum structural break is endogenously determined by the FORTRAN programming language based on the optimum or lowest SIC value. So now we tried to show what would happen if FMBP methods were introduced.

In Figure 5, we have presented the results of structural breaks in the growth of India's GDP coming from the manufacturing sector using FMBP methods. The figure shows there are five regimes and four breaks in the growth path.



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

Figure 5: Breaks in linear growth path of India's GDP coming from the manufacturing sector using the FMBP method

Table 4 shows the optimum SIC value is -6.7588, which quite differs from the results of the Bai and Perron methods. The coefficient of the H model shows the growth rate of each period, and the p-value shows the significance of the growth. The term 'H model' does not imply any additional complexity; it is simply a way to present the growth rate for each period using a regression model, where each period is denoted as H1, H2, and so on. This is why we refer to it as the H model. The p-value of the H model shows significance. Here, one upward spike (inverse V-shape) is created between the first and second regimes. For the first break, two years created high growth at 9.38%, and the next two years, it fell to -0.15%. Break 2 created a downward spike (V-shape) where, for the year, the growth rate fell to 2.14%, and the next two years created a high growth at 13.69% and continued its third regime at 4.68% for the years 1996–97 to 2003–04. This means there are not so significant upward or downward jumps; the growth rate just creates a downward spike between the two regimes. So here, if we introduce either Boyce's method or Bai & Perron's method, that obviously creates a wrongly high growth because if we only introduce a single-year crash, then from that point start a new regime that obviously has high growth, but that is not a true picture of the data set. Third break also creates a downward spike where, for the years 2004-05 to 2005-06, the growth rate increases to 8.91%, and the next year creates massively high growth at 17.40% and continues its fourth regime at 6.16% for the years 2007-08 to 2014-15. Break Four creates high growth at 14.52%.

Table 4: Results of Breaks in Linear Growth Path Of India's Gdp Coming From The Manufacturing Sector Using The Further Modified Bai and Perron (Fmbp) Method

Break in GDPM using FMBP					
SIC				-6.7588	
R-square=				0.9995	
Adjusted R Square				0.9993	
F=				5713.0	
Significance F=				1.3E-56	
			Coeffi.	*P-value*	*Year (Duration)*
		Intercept	11.7440	4.0E-75	
Regime1		H1	0.0380	1.7E-10	1970-71 to 1976-77 (7)
Upward Spike	Break 1	H2	0.0938	2.5E-08	1977-78 to 1978-79
	Break 1	H3	-0.0015	9.0E-01	1979-80 to 1980-81
Regime2		H4	0.0554	4.7E-27	1981-82 to 1991-92 (11)
Downward Spike	Break 2	H5	0.0214	8.8E-02	1992-93 to 1993-94
	Break 2	H6	0.1369	6.4E-13	1994-95 to 1995-96
Regime3		H7	0.0468	3.1E-18	1996-97 to 2003-04 (8)
Downward Spike	Break 3	H5	0.0891	1.1E-07	2004-05 to 2005-06
	Break 3	H6	0.1740	7.3E-08	2006-07
Regime4		H7	0.0616	1.9E-21	2007-08 to 2014-15 (8)
Double Kink	Break 4	H10	0.1452	3.7E-07	2015-2016
Regime5		H11	0.0469	3.0E-07	2016-17 to 2019-20 (4)

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

The last regime is a truncated regime for the years 2016–17 to 2019–20. As the last regime is very low compared to the fourth regime, the growth difference is also insignificant. The highest growth rate achieved in the fourth regime is 6.16% for the years 2007–08 to 2014–15 for eight years. The detailed results of the structural break of India's GDP coming from the manufacturing sector using the FMBP method are shown in Table 4.

We have examined the fundamental features of the structural break in the linear growth path that has occurred in India's GDP coming from the manufacturing sector. It has been observed that an overall total of five regimes have been created, consisting of four complete-length regimes and one truncated regime. There are four distinct breaks that can be identified: the first is characterised by an upward spike, the second consists of two downward spikes, and the third exhibits a double kink (one-year sub-period) or intercept change only.

VII. CONCLUSION

India's manufacturing sector output has grown significantly, at 6.08% per annum, for the last fifty years, from 1970–71 to 2019–20. For structural break estimation, we have used Boyce [4], Bai and Perron [2][3] and our proposed Further Modified Bai and Perron (FMBP) method. For all three methods, we set a FORTRAN algorithm and estimated structural breaks endogenously with the simultaneous method. The major limitation is that neither [4] kink method nor Bai and Perron's [2][3] one-year subperiod break estimation method may give a true picture of structural breaks in time series data. In FMBP, we considered that there may be kinks, one- or two-year subperiods, or V-shape breaks between two growth regimes. We also consider truncated regimes at both ends of the growth cycle. We have considered a 7-year minimum length of regime, and for a truncated regime, it is 4 years. From 1970–71 to 2019–20, India's manufacturing sector output growth created four regimes, which are five regimes. Out of five regimes, four are full-length regimes, and one is a truncated regime for four years, which occurred in the last regime. One upward spike, two downward spikes, and one double kink create one-year subperiods in India's manufacturing sector. The truncated regime concept is also newly incorporated into the existing literature.

CONFLICTS OF INTEREST

The authors declare that they have no conflicts of interest.

REFERENCES

1. D. W. Andrews, "Tests for parameter instability and structural change with unknown change point," Econometrica, vol. 61, no. 4, pp. 821–856, 1993. Available from: https://doi.org/10.2307/2951764
2. J. Bai and P. Perron, "Estimating and Testing Linear Models with Multiple Structural Changes," Econometrica, vol. 66, pp. 47–78, 1998. Available from: https://doi.org/10.2307/2998540
3. J. Bai and P. Perron, "Computation and Analysis of Multiple Structural Change Models," Journal of Applied Econometrics, vol. 18, no. 1, 2003. Available from: https://doi.org/10.1002/jae.659
4. J. K. Boyce, "Kinked exponential models for growth rate estimation," Oxford Bulletin of Economics and Statistics, vol. 48, pp. 385–391, 1986. Available from: https://doi.org/10.1111/j.1468-0084.1986.mp48004007.x
5. R. H. Dholakia and A. Sapre, "Estimating Structural Breaks Endogenously in India's Post-Independence Growth Path: An Empirical Critique," Journal of Quantitative Economics, vol. 9, pp. 73–87, 2011. Available from: http://dx.doi.org/10.2307/4416428
6. P. Perron, "The Great Crash, the Oil Price Shock, and the Unit-Root Hypothesis," Econometrica, vol. 57, no. 6, pp. 1361–1401, 1989. Available from: https://doi.org/10.2307/1913712
7. P. Perron and X. Zhu, "Structural breaks with deterministic and stochastic trends," Journal of Econometrics, vol. 129, pp. 65–119, 2005. Available from: http://dx.doi.org/10.1016/j.jeconom.2004.09.004
8. D. Pradhan and D. Mondal, "Growth and Fluctuation in India's GDP and Sectoral GDP: 1970–71 to 2019–20," Vidyasagar University Journal of Economics, vol. XXVII, pp. 125–139, 2023. [Online]. Available from: http://inet.vidyasagar.ac.in:8080/jspui/handle/123456789/6944
9. D. Pradhan and D. Mondal, "Relative Importance of Openness Index and Crude Oil Price in Explaining Growth of India's GDP During 1970–71 to 2019–20," International Journal of Innovative Research in Engineering and Management (IJIREM), vol. 10, no. 6, pp. 60–65, 2023. Available from: https://doi.org/10.55524/ijirem.2023.10.6.9
10. E. Zivot and D. Andrews, "Further evidence of great crash, the oil price shock and unit root hypothesis," Journal of Business and Economic Statistics, vol. 10, pp. 251–270, 1992. Available from: https://doi.org/10.2307/1391541