Economic Growth and Structural Beaks: Results from the Generalized Fluctuations Tests and Recent Algorithms

Prashobhan Palakkeel
Assistant Professor,
Amrita School of Business,
Amrita Vishwa Vidyapeetham,
Ettimadai, Coimbatore
p_prashobhan@cb.amrita.edu,

Jisha KK
Assistant Professor,
Department of Economics,
Government College Chittur,
Palakkad, Kerala-.
jishukrishnadas@gmail.com,

Abstract

Recent studies on structural changes and economic growth of the Indian economy identify some distinguished patterns compared with the other high-growing economies in the Asian region. The new paradigm evolves around the persistence of high-level employment in the agriculture sector while there is a significant decline in the output share from the sector. The unprecedented expansion of the tertiary sector before the manufacturing sector expanded sufficiently was also seen as an aberration from the growth paths of other regional forerunners. In this study, we tried to identify the structural breaks in the Indian economy with special reference to the agriculture sector. Apart from generalized fluctuations tests, we employed recently developed algorithms like segmented modeling based on a score-based approach to identify potential breaks. Recent algorithms suggest four break points (1970-71 to 2021-22), and generalized fluctuations tests confirm the same. The identified structural breaks can be used as reference periods to describe the growth dynamics.

Key Words: *Economic Growth, Agricultural Credit, Structural Breaks, Chow test, CUSUM test, MOSUM test, Kinked Exponential Growth, Score-Based test.*

JEL: *Q14, C22, C50*

Introduction

Amidst the global economic slowdown, the Indian economy has shown signs of recovery and moved ahead after facing the challenges of the COVID-19 pandemic. Many international agencies project India as the fastest-growing critical economy, with a growth rate above 6.5 percent in 2022-23. However, the initial estimates show an impressive 7.24 percent growth rate for the last year. This tremendous achievement gives financial institutions enough confidence to support various economic activities through institutional credit. More specifically, a significantly ameliorated public sector banks' financial health helps them enhance credit deployment. The primary sector substantially contributes to the economy's growth with its strong forward linkages apart from ensuring food security. In India, the fruition of the agriculture and allied sectors remains crucial to the development and employment of the country as it contributes 18.29 percent of gross value added (2019–20) and provides work for 45.6 percent of the total workforce (Chand & Singh,2022).

Reports (GOI,2022-23) show that India's agriculture sector has grown at 4.6 percent per annum in the last six years. Similarly (RBI, 2022), against the target, banks in India have achieved 104 percent of the agriculture credit delivery in March for the year 2021-22. Moreover, the observations show that the buoyancy in the agriculture sector is reflected in the sales of tractors and fertilizers during the period. India has systematically pursued a supply-leading approach in agriculture credit delivery by understanding the importance of credit in enhancing input usage, technological change, and technical efficiency, eventually leading to stable output growth. The overall thrust of the government's credit policy assumes credit is an essential input that can establish causality with productivity and overall growth and provides a channel to intervene in the process.

India has witnessed several significant policy reforms in the last five decades. The Liberalisation-Privatisation-Globalisation (LPG) program implemented in the early nineties and progressed over the years is remarkable. It completely changed the structure and prospects of the economy. A recent economic survey (GOI,2022-23) shows that the Indian economy has undergone a revamping "New Age" reform process in the last eight years. The government aims for fundamental economic structure changes due to ongoing reforms. However, the global economy has witnessed a few devastating economic crises like the East Asian Crisis (1997-98), the subprime crisis (2007-08), and the COVID-19 pandemic (2020), and they have impacted the smoother transition of the intended economy by the reforms. It is essential to see the impact of these policy reforms and economic crises on the fundamental flows in the economy. This paper tries to identify structural breaks in the total agriculture credit in India from 1970-71 to 2021-22. It assesses major developments that could have contributed to the significant changes during the periods.

Many studies have tried to evaluate the impact of policy reforms on the Indian economy, and some have criticized the earlier frameworks' effectiveness. Some studies show that the reforms in the nineties could have been faster-paced and broken (Ahluwalia, 2002). The lack of supplementary reforms, especially in the labor markets, and the deteriorated fiscal conditions of the state governments created hurdles in achieving the targets. The wrong design and architecture of the credit delivery schemes lead to failure in achieving the targets (Satyasai, 2008). Due to its design, the multiagency system introduced for easy access to agriculture credit could have been more effective. Other than commercial banks, other agencies involved in the schemes could not function as expected. Disparities in the inter-state credit flow have decreased after liberalization, but insufficient coverage has remained the same in most Indian states (Khan, Tewari, & Shukla, 2007).

The Reserve Bank of India introduced a licensing policy for the new branches in 1977, which directed the opening of more branches (1:4) in the rural areas to get new branch licenses in the already opened locations. Burges & Pande (2005) provide clear evidence for the policy's success in achieving the targets.

Their study results clearly show that expanding branches in the rural unbanked areas helped reduce poverty in those areas. Moreover, trend reversals are observed in their study between 1977 and 1990 and post-1990.

Kumar (2004) observed a significant fall in the rural credit deployment by commercial banks as a share of their total credit disbursement after 1991. His results show that Perron's model (1989) does not fit well while modeling the breaks in the credit supply. Pal & Sapre (2010) tried to identify the possible break points in the credit outstanding series using Bai & Perron's (1998, 2003) method. They found three possible breaks (1981,1989, and 1991) between 1969 to 2009. Besides the first one, two different breakpoints are very close to the points identified by Burgess & Pande (2005). Roy et.al (2014) explored the structural breaks in other sectors in a unit root testing framework and found four break points. In a recent study, Akber & Paltasingh (2021) observed an overall decline in public sector investment in agriculture while comparing the share of GDP and GDCFA. They identified five break points in the case of private investment (1968, 1988, 1997, 2004, and 2011) and four in the case of public investment (1968, 1976, 1988, and 2003) following the Bai-Perron method.

Structural Breaks in the Agricultural Credit Delivery

Direct lending to farmers by institutional agencies includes both short-term and long-term credit. A manifold increase in the volume of direct agricultural credit can be seen in the last five decades. The efforts to enhance the credit flow to agriculture and allied activities yielded exemplary results and credit to agriculture. The annual average for the previous decade (2010-11 to 2019-20) reached around 18 percent. However, it may be noted that it has not been a smooth ride over all these years, and it has witnessed quite a dramatic variation. Interestingly, the institutional flow of credit to agriculture has risen continuously since the 1950s and continued until the 1980s. Although there were some disruptions in some years, the average growth during the 1990s was better than in the 1980s.

Commercial and regional rural banks dominated rural credit expansion in the 1980s and 1990s. Inevitably, a fall in the share of co-operatives has been witnessed during the period. The percentage of priority sector advances in total credit increased to 43.6 in 1986 (RBI,1986), which surpassed the national target of 40 percent. The performance of public sector banks in lending to the priority sector, especially in the post-nationalization period, was remarkable.

In 1986, GOI revised the earlier 20-point program. Under the modified program, various instructions were put forward for bank finance. As a result, public sector banks had extended financial assistance under the new program by 7897 crores. The 152 lacks borrowed accounts formed 33.2 percent of their priority sector advances. Nationalization of commercial banks and large-scale branch expansion were undertaken to cater to a solid institutional base in rural areas.

The public sector banks increased their lending under priority sector advances from Rs 38,649 crores at the end of June 1990 to Rs 42,039 crore at the end of June 1991. However, the share of priority sector lending in total bank credit has fallen from 44.6 percent (at the end of June 1989) to 42.3 percent (at the end of June 1990) and to a further 40.9 percent (at the end of June 1991). This decline was more pronounced in agricultural advances. However, during the period, the government has written off some of the rural debt under the Agricultural and Rural Debt Relief Scheme 1990. The Central Budget for 1990-91 introduced a debt relief scheme under which the government waived outstanding loans up to Rupees 10000 for the non-wilful defaulter engaged in agriculture and other allied activities. Indian economy faced many uncertainties in 1990-91. Persistent fiscal imbalances and the Gulf War crisis intensified strain on an already weakened BOP position of the Indian economy during the year.

ISBN: 978-93-83302-64-2

After 1990-91, there was a significant improvement in the growth of agriculture credit delivery in the economy, and in 1995-96, it reached a peak of 26.2 percent growth per annum. After that, there was a considerable deceleration in the agriculture credit growth, and the average increase was around 11 percent for the next three years. Many countries worldwide, especially in Asia, were affected by the economic crisis (South East Asian crisis) in these years. In 1998-99, the Kissan Credit Card scheme was introduced in India to ensure hassle-free credit for eligible farmers. In 1999-2000, the agriculture credit growth again climbed back with an annual increase of 39.3 percent.

The next decade also started with a dip in agriculture credit growth. In 2000-01, agriculture credit growth came down to 5.83 from 39.3 percent. In the next few years, agriculture credit grew very consistently and reached 36.77 percent in 2005-06. The average growth rate for the decade was around 20 percent per year. However, the credit growth decelerated from 2006-07, and the global economy faced a financial crisis for the next few years. During 2007-08 the growth rate came down to 2.87 percent. But the situation has significantly improved in the later years. There was a systematic growth in credit deployment in the early years of the next decade. The annual growth rate was around 32 percent in the first three years. However, from 2015-16 onwards, credit growth was significantly decelerated. The average credit growth rate for the decade was lower than the previous decade (17.6 percent).

An evaluation of the annual growth rate of agricultural credit deployment shows significant variations during the last five decades (Table 1). Vibrant changes in the policy frameworks and a few economic crises worldwide made it susceptible to structural breaks. These incidents affected almost all economic activities at different levels. Some of the changes are significantly deeper and structural in nature. The present study explicitly investigates such changes in agricultural credit delivery. We used the data on direct institutional credit for agriculture to evaluate the structural changes in agricultural credit delivery. For this study, we considered two primary aggregates (loan issued and outstanding). Although agency-wise data is available, we use only the aggregates to understand the overall trend. We have considered the period from 1970-71 to 2021-22. The data is depicted in Figures 1 and 2 (log-transformed). Log transformation mostly linearised the series.

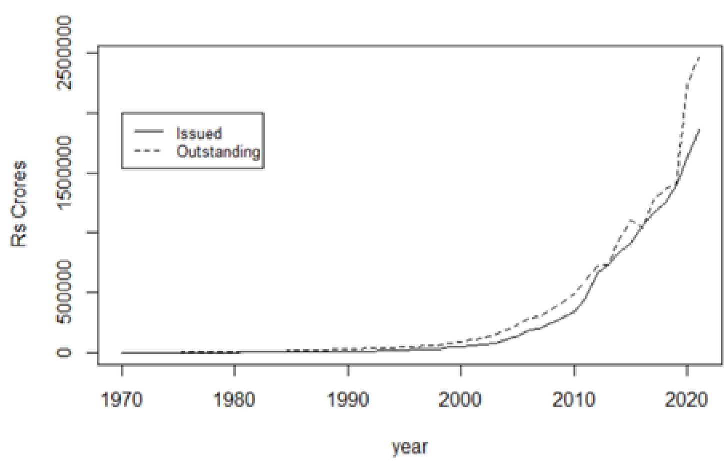

Figure 1

Total Loan Issued and Outstanding over the Years

ISBN: 978-93-83302-64-2

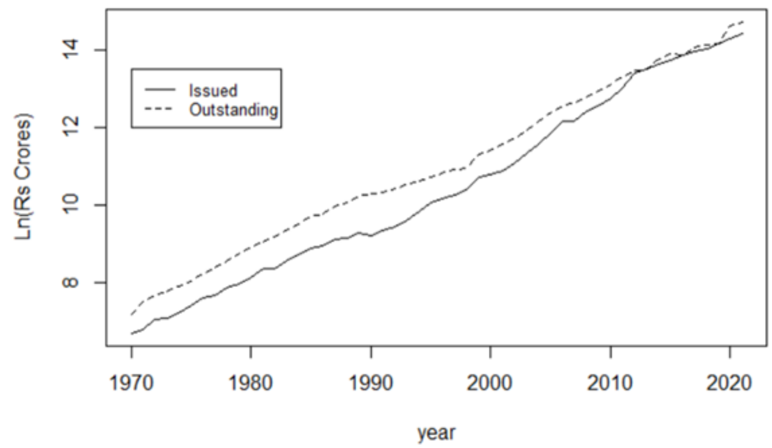

Figure 2

Total Loan Issued and Outstanding Over the Years (log-transformed).

Table 1

Percentage Annual Growth Rate in Total Agricultural Loan Issued

Year	Growth rate	Year	Growth rate	Year	Growth rate
1971-72	7.92	1990-91	-4.14	2009-10	16.43
1972-73	30.9	1991-92	13.25	2010-11	20.42
1973-74	2.69	1992-93	8.6	2011-12	32.01
1974-75	17.22	1993-94	19.82	2012-13	44.83
1975-76	20.39	1994-95	25.05	2013-14	10.73
1976-77	21.63	1995-96	26.2	2014-15	15.78
1977-78	5.82	1996-97	11.2	2015-16	8.3
1978-79	22.54	1997-98	8.77	2016-17	16.41
1979-80	10.87	1998-99	14.1	2017-18	9.09
1980-81	17.33	1999-00	39.26	2018-19	8.1
1981-82	25.03	2000-01	5.83	2019-20	10.81
1982-83	1.31	2001-02	12.47	2020-21	16.9
1983-84	20.51	2002-03	20.26	2021-22	14.45
1984-85	17.59	2003-04	28.01		
1985-86	16.08	2004-05	26.22		
1986-87	7.84	2005-06	36.77		
1987-88	19.15	2006-07	31.59		
1988-89	1.98	2007-08	2.87		
1989-90	13.3	2008-09	26.17		

Source: Authors' calculation

ISBN: 978-93-83302-64-2

Methodology

Many methods are available for testing the breakpoints in the time series data. Some tests involve the selection of breakpoints, which can be very subjective, and others don't require such specifications. Chow Test and Boy's exponential growth models are the first category and require an exact selection of the breakpoints. Methods in the second category are Bai-Perron (2003) and Muggeo V M (2016). As many authors have already employed the Bai-Perron (2003) methods in the Indian context, in this paper, we focus on the procedure developed by Muggeo V M (2016) for identifying the breakpoints, and the method is based on the score statistic. We also verify the results using traditional methods (Chow Test and Boy's exponential growth models). We used R.4.2.2 for data analysis, estimation, and graphics.

Identifying Structural Breaks and Segmented Modeling Based on a Score-Based Approach (Muggeo V M,2016)

Let the function $\varphi(x,\psi)$ relates the variables y and x and the scalar parameter is known as $\psi \in [\mathcal{L},\mathcal{U}]$. The relationship between the variables can be represented as a regression equation

$$\mu_i = z_i^T\beta + \delta\varphi(x_i\psi) \quad i = 1,2,3,\ldots\ldots,n \qquad (1)$$

Where the mean of y_i, $\mu_i = E[y|x_i z_i]$ and z_i is a vector of extra explanatory variables entering the model. In the presence of structural change, we can have many versions of model 1. Our main objective is to test he hypothesis H_0: $\delta = 0$ against H_1: $\delta \neq 0$. ψ exists only if $\delta \neq 0$. In order to test the hypothesis, we follow the procedure explained in Muggeo V M (2016).

The test statistic based on the score can be computed as

$$s_0 = \frac{\bar{\varphi}^T(I_n - A)y}{\sigma(\bar{\varphi}^T(I_n - A)\bar{\varphi})^{1/2}} \qquad (2)$$

Under the null hypothesis ($\delta = 0$), the score statistic follows the standard normal distribution.

We have log transformed the credit series (y) and the transformation has mostly linearised the series (Figure.2). So, we assume that a linear time trend could sufficiently explain the log-run characteristics of the series and we avoid additional explanatory variables in the model.

Generalized Fluctuation Tests

Consider another common specification of the regression equation (1)

$$y_i = x_i^T\beta_i + u_i \qquad i = 1,2,3,\ldots\ldots,n \qquad (3)$$

Generalized fluctuation tests can be set based on the model estimates or regression residuals. Some of the most famous tests are conducted on the cumulative sums of residuals. Following Brown, Durbin & Evans, 1975 and Ploberger & Kramer (1992), the ordinary least squares-cumulative sum of residuals(OLS-CUSUM) type of empirical fluctuation process can be specified as

$$W_n^0(t) = \frac{1}{\tilde{\sigma}\sqrt{\eta}}\sum_{i=1}^{[t\eta]}\tilde{u}_i \quad (0 \leq t \leq) \qquad (4)$$

Where η=n-k is the number of recursive residuals and [tη] is the integer part of tη. The limiting process is the standard Brownian bridge.

Another alternative is based on the moving sums of residuals (MOSUM). The recursive MOSUM process can be represented as

$$M_n^0(t|h) = \frac{1}{\hat{\sigma}\sqrt{\eta}}\left(\sum_{i=[N_n t]+1}^{[N_n t]+[nh]} \hat{u}_i\right) \quad (0 \leq t \leq 1-h) \qquad (5)$$

Where $N_n=(n-[nh])/(1-h)$. The limiting process is the increment of a Brownian motion.

The structural break is identified based on the crossing over by the empirical fluctuation process, efp(t) on some appropriate boundary b(t). The standard boundaries for the Recursive CUSUM and the OLS-based CUSUM process are of type

$b(t)=\lambda.(1+2t)$

$b(t)=\lambda.$

Where λ determines the confidence level.

F tests

Based on the regression model (3) we specify

$$\beta_i = \begin{cases} \beta_A(1 \leq i \leq i_0 \\ \beta_B(i_0 < i \leq n \end{cases}$$

Where i_0 is the change point in the interval(k,n-k).

The Chow (1960) test static based on two sub-samples can be represented as

$$F_{i0} = \frac{\hat{u}^T\hat{u} - \hat{e}^T\hat{e}}{\hat{e}^T\hat{e}/(n-2k)} \qquad (6)$$

Where $\hat{e} = (\hat{u}_A, \hat{u}_B)^T$ are the residual from the full model and $\hat{u}$ are from the restricted model

The F test can be extended for multiple periods or possible break points in a given time range [$\underline{i}$ $\bar{\iota}$]. Three aggregate measures of F for the given interval (Andrews ,1993 and Andrews and Ploberger ,1994) can be expressed as

$$supF = \sup_{\underline{i} \leq i \leq \bar{\iota}} F_i \qquad (7)$$

$$aveF = \frac{1}{\underline{i} - i + 1}\sum_{i=\underline{i}}^{\bar{\iota}} \exp(0.5F_i) \qquad (8)$$

$$expF = \log\left(\frac{1}{\underline{i} - i + 1}\sum_{i=\underline{i}}^{\bar{\iota}} exp(0.5F_i)\right) \qquad (9)$$

Under Bai and Perron's (2003) method the optimum segmentation for a given interval can be achieved by minimising the residual sum squares for the recursion

$$RSS(I_{m,n}) = \min_{mn_h \le i \le n-n_h} [RSS(I_{m-1,i}) + rss(i+1,n)] \quad (10)$$

Where $rss(i_{j-1}+1, i_j)$is the minimal residual sum of squares in the j[th] segment and RSS is the total summation.

Boyce's Kinked Exponential Model for the Growth Rate

Let we denote the kink points as $k_1,\ldots\ldots,k_{m-1}$ and subperiod dummy variables as $D_1,\ldots\ldots$, D_m .The generalized kinked exponential model for *m* subperiods and *m-1* kinks can be represented as

$$lnY = \alpha_1 + \beta_1\left(D_1 t + \sum_{j=2}^{m} D_j\, k_1\right) + \beta_2\left(D_2 t + \sum_{j=2}^{m} D_j\, k_1 + + \sum_{j=3}^{m} D_j\, k_2\right) + \cdots$$
$$+ \beta_i\left(D_i t + \sum_{j=i}^{m} D_j\, k_{i-1} + + \sum_{j=i=1}^{m} D_j\, k_i\right) + \cdots + \beta_m(D_m t - D_m k_{m-1}) + \varepsilon_t \quad (11)$$

The equation can be estimated using ordinary least squares and the β's gives the exponential growth rates for the subperiods. If $\beta_i \neq \beta_j$, we expect the presence of a kink in the trend line

Results and Discussion

Generalized fluctuation tests are helpful to identify potential breaks areas in time series. OLS-based CUSUM test on the empirical fluctuation process clearly indicates potential breaks in the period between 1985to 1987 and 2002 to 2012 (Figure.3). The boundaries are significant (asymptotic) at 5% level. We will make similar conclusion from the F-test(*supF*) results (Figure.4). The boundaries in the figure corresponding to 5% level of significance(*supF*). Based on the residual triangular matrix(rss(i;j)), the arbitrary m-segment models gives 4 optimal break points (Figure.5). We use a trimming value of 0.15 for *h*.

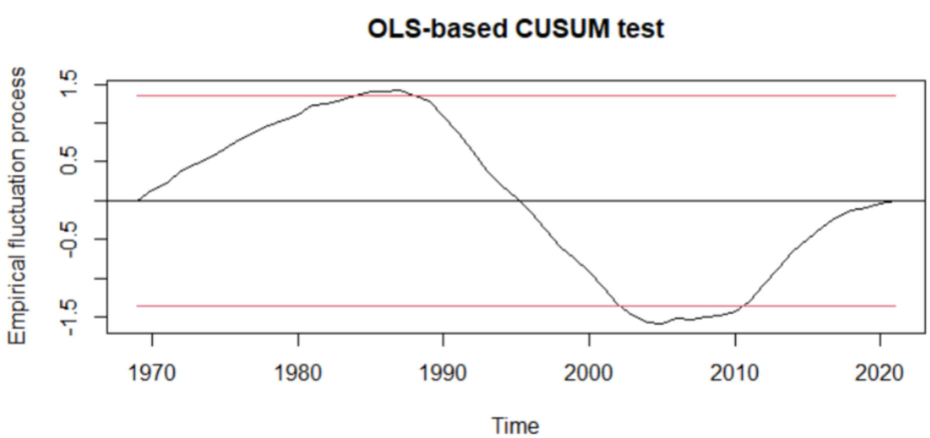

Figure.3

OLS-based CUSUM test on the empirical fluctuation process.

ISBN: 978-93-83302-64-2

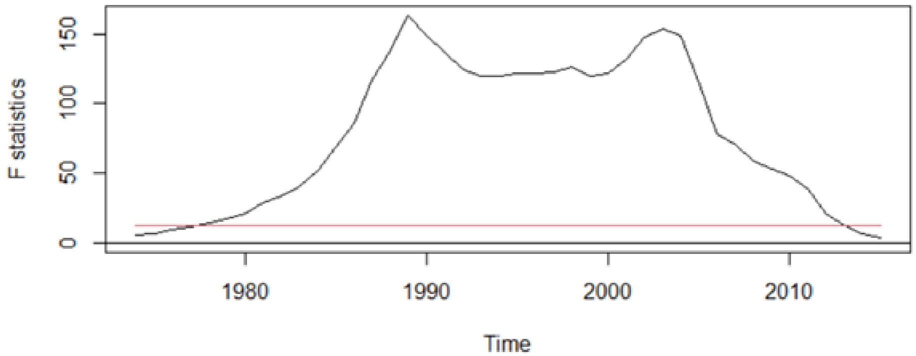

Figure.4

F-test

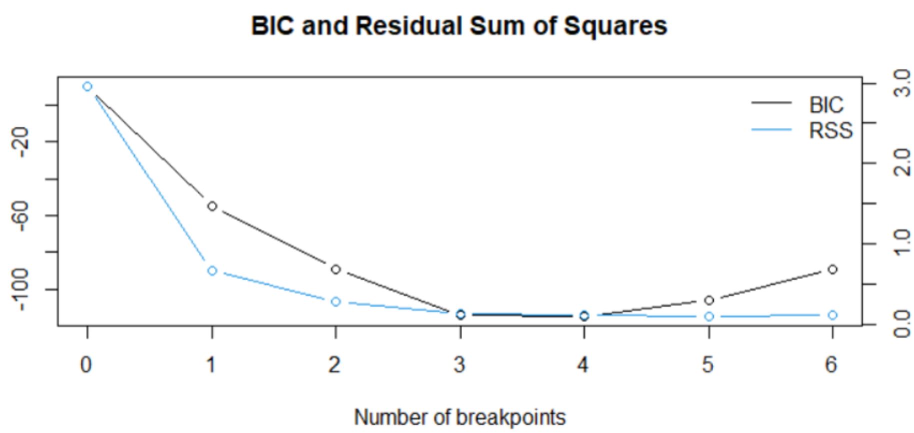

Figure.5

Optimal break points

The new generations tests/algorithms do not require specifying break points explicitly. Because of this advantage over the traditional methods, we employ the dynamic algorithm by (Bai & Perron,2003) and scoring method (Muggeo,2016) in the first stage. Both tests suggest four break points across the time period (1970-71 to 2021-22). The first two break points are similarly suggested by both algorithms but slightly differs in the later cases (Table.2). As per the sore test result, among these breaks, the second period is the shortest, and third one is the most modest (Figure.6, Table.3). Interestingly, Chow test results also justifies the findings from the score test. All the estimated coefficients from these tests are significant at 1% level (Table.4). In the case of Boyce's kinked model results, all the estimated coefficients are statistically significant at 1% level. However, the estimated coefficients of last two periods are the same (after rounding off). Which could be interpreted as absence of kink (no breaks) between the last two periods (Table.5). However, based on majority of the tests (Bai and perron test, score test and Chow test (and other F-tests) results, we conclude that, there can be four optimal break points during the chosen time period.

ISBN: 978-93-83302-64-2

Table.2

Break points suggested by different tests

	Bai and Perron		Muggeo	
S no	Point	Year	Point	Year
1	18	1987	17.8	1987
2	23	1992	21.7	1991
3	35	2004	32.4	2002
4	42	2011	44.2	2014

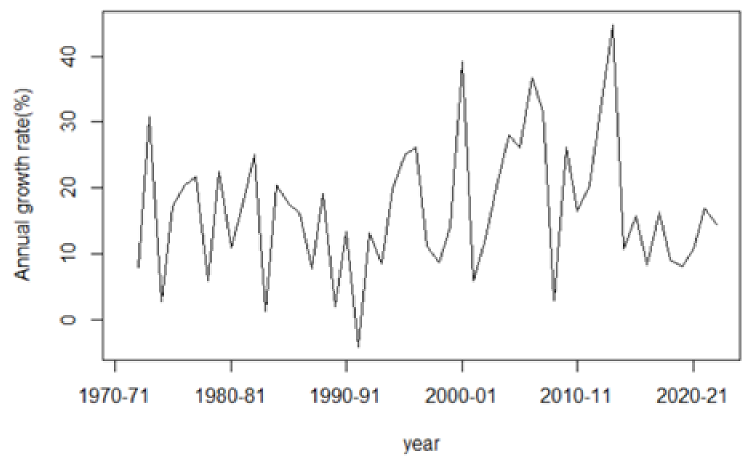

Figure.4

Percentage Annual Growth Rate in Total Agricultural Loan Issued

Table.3

Results from the score-based test

Estimated Break-Point				
	Estimates	Standard Error		
psi1.x	17.816***	0.595		
psi2.x	21.71***	0.618		
psi3.x	32.396***	0.922		
psi4.x	44.214***	0.526		
Meaningful coefficients of the linear terms				
	Estimate	Standard Error	t-value	p-value
Intercept	6.551979	0.029557	221.67	<2e-16
x	0.14418	0.002884	49.985	<2e-16
U1.x	-0.10104	0.026215	-3.854	
U2.x	0.118239	0.026642	4.438	
U3.x	0.052852	0.007389	7.153	
U4.x	-0.10361	0.010226	-10.13	

ISBN: 978-93-83302-64-2

Residual standard error: 0.058 on 42 degrees of freedom Multiple R-Squared: 0.9995, Adjusted R-squared: 0.9994
Boot restarting based on 8 samples. Last fit: Convergence attained in 2 iterations (rel. change 2.91e-11)

Table.4

Chow-test for structural breaks results.

Sno	Break Point	F-value	p-value
1	1986	13.7738	0.000***
2	1990	8.43581	0.006***
3	2001	22.0782	0.000***
4	2013	35.6814	0.000***

*** Indicates significance at 1% level

Table. 5

Boyce's kinked exponential growth rate test results.

Period	Coefficients	Estimates	t-Statistic	P-value
	Intercept	6.62	104.56	2.4E-56
1970-86	Dtk1	0.13	24.60	4.07E-28
1987-90	Dtk2	0.18	11.82	1.52E-15
1991-00	Dtk3	0.16	16.99	1.88E-21
2001-10	Dtk4	0.17	31.27	1.22E-32
2011-21	Dtk5	0.17	41.54	4.02E-38
		F-value	3227.3	2.44E-57
		AdjR^2	0.997	

ISBN: 978-93-83302-64-2

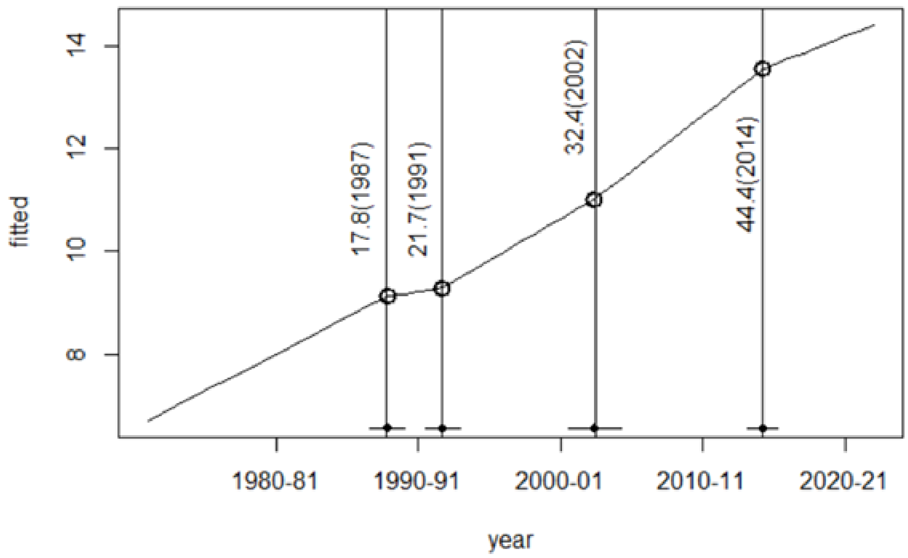

Figure.6
The Fitted Model

While looking at the break points, the annual average growth rates give some description about the changes in the trends. The average annual growth rate during the period 1988-89 to 1990-91 was around 3.7 percent and it is the lowest across three consecutive years in the last five decades (Table.4, Figure.4). Moreover, 1990-91, the crisis year has the only negative growth rate (-4.14). In the period before (1971-72 to 1987-88), the average growth rate was around 15.6 percent. For the next period (1992-93 to 2001-02) the average growth rate increased to 17.13 percent. During the next period (2002-03 to 2013-14), the average growth was further increased to 24.7 percent. However, in the following period (2014-15 to 2021-22) the average growth rate has decreased to 12.48 percent.

If we compare the previous results, two break points identified in Pal & Sapre (2010) are mostly near to (1989-1990,1999-2000) the break-points identified in this study. However, the findings of Akber & Paltasingh (2021) are different from our study. It is quite surprising that the negative growth rate in the year of 1990-91 did not get captured in their analysis. Present study extent the period much beyond the earlier studies and it employed one of the recently developed methodologies. The results from the study have many policy implications and it will provide more insights for framing the policies for long-term and especially for rural development.

Conclusion

During the past five decades Indian economy has undergone significant transformations. Vibrant policy reforms and many economic catastrophes happened around the world during the same period. From a traditional agrarian economy, Indian economy has emerged as one of the most diversified and powerful economies around the world. All these transformations were not smooth and many of them are very deeper and structural in nature. Agriculture credit play a significant role in the rural transformations in India. Present study tried to explore the structural breaks in the agriculture credit deployment. Apart from traditional tests, present study employed dynamic algorithms (Bai & Perron,2003) and recently developed score-based test (Muggeo, 2017). Test results suggests four break points during period of the study. Compared to the traditional tests, modern tests are much powerful and the available algorithms provides very comprehensive test results and very easy to use.

References

Ahluwalia, M, S. (2002). Economic Reforms in India Since 1991: Has Gradualism Worked? *Journal of Economic Perspectives*, 16(3), 67-88. DOI: 10.1257/089533002760278721

Akber, N., & Paltasingh, K., R. (2021). Agricultural Growth and Investments in India: Assessment of Recent Trends, Breaks and Linkages, *Italian Review of Agricultural Economics* 76(2), 17-30. DOI: 10.36253/rea12057

Bacon, D.W., & Watts, D.G., (1971). Estimating the transition between two intersecting straight lines. Biometrika 58(3), 525 – 534. https://doi.org/10.2307/2334387

Bai J., & Perron P. (2003). Computation and analysis of multiple structural change models. Journal of Applied Econometrics, 18(1): 1-22. https://doi.org/10.1002/ jae.659

Boyce, J.K. (1986). Kinked compound models for growth rate estimation. *Oxford Bulletin of Economics and Statistics*, 48(4), 385-391. https://doi. org/10.1111/j.1468-0084. 1986.mp48004007.x

Burgess, R. & Pande, R. (2005). Do Rural Banks Matter? Evidence from the Indian Social Banking Experiment, *The American Economic Review*, 95(3), 780-795. DOI: 10.1257/0002828054201242

Chand, R., & Singh, J. (2022). Workforce Changes and Employment Some Findings from PLFS Data Series, NITI Aayog Discussion Paper 1/2022. https://www.niti.gov.in/sites/default/files/2022-04/Discussion_Paper_on_Workforce_05042022.pdf

Chow, G.C. (1960). Tests of equality between sets of coefficients in two linear regressions. *Econometrica*, 28(3), 591-605. https://doi.org/10.2307/1910133

Davies, R.B. (1987). Hypothesis testing when a nuisance parameter is present only under the alternative, *Biometrika* 74(1), 33–43. https://doi.org/10.2307/2336019.

Pal, D., & Sapre, A. (2010). How have Government Policies Driven Rural Credit in India: A Brief Empirical Analysis, 1969-2009 W.P. No. 2010-12-02, IIM Ahmedabad. https://ideas.repec.org/p/iim/iimawp/wp2010-12-02.html

Government of India (2023) Economic Survey, Ministry of Finance Department of Economic Affairs Economic Division North Block New Delhi-110001. https://www.indiabudget.gov.in/economicsurvey/doc/echapter.pdf

Khan, A. R., Tewari, S. K., & Shukla, A. N. (2007). Effect of Liberalization on Institutional Agricultural Credit Flow and its Relationship with Average Cost of Cultivation in Indian Agriculture, *Agricultural Economics Research Review*, 20, 227-234.

https://www.indianjournals.com/ijor.aspx?target=ijor:aerr&volume=20&issue=2&article=003

Kumar, A. (2004). Declining Trend in Rural Credit Delivery in India: A Trend Break Analysis of Univariate Series. http://dx.doi.org/10.2139/ssrn.605522.

Muggeo, V.M.R., Atkins, D.C., Gallop, R.J., & Dimidjian, S. (2014). Segmented mixed models with random changepoints: a maximum likelihood approach with application to treatment for depression study, *Statistical Modelling*, 14(4), 293-313. https://doi.org/10.1177/1471082X13504721

Muggeo, V.M.R. (2003). Estimating regression models with unknown break-points, *Statistics in Medicine*, 22(19), 3055–3071. https://doi.org/10.1002/sim.1545

ISBN: 978-93-83302-64-2

Muggeo, V.M.R. (2016). Testing with a nuisance parameter present only under the alternative: a score-based approach with application to segmented modelling, *Journal of Statistical Computation and Simulation*, 86(15), 3059–3067. https://doi.org/10.1080/00949655.2016.1149855

Muggeo, V.M.R. (2017). Interval estimation for the breakpoint in segmented regression: a smoothed score-based approach, *Australian & New Zealand Journal of Statistics*, 59(3), 311–322. https://doi.org/10.1111/anzs.12200

Roy Choudhury, Purba Chatterjee, Biswajit (2014). Multiple Structural Breaks and Unit Root Hypothesis: Evidence from India's Service Sector. [S.l.] : SSRN. https://ssrn.com/abstract=2419947. https://doi.org/10.2139/ssrn.2419947.

Reserve Bank of India (2022) Annual Report, Mumbai. https://www.rbi.org.in/Scripts/AnnualReportPublications.aspx?year=2022

Satyasai, K. J. S. (2008). Rural Credit Delivery in India: Structural Constraints and Some Corrective Measures, *Agricultural Economics Research Review*, 21, 387-394. DOI: 10.22004/ag.econ.47889

Seber, G.A.F., & Wild, C.J. (1989) Nonlinear Regression. Wiley, New York.