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Structural Break Time in Some Variables Related To Rice Production in Assam

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ABSTRACT

This research examines the structural break points in rice for area, production and productivity in Assam using annual time series data spanning the years from 1990 through 2015. The structural changes occur during the sample period. Thus after applying unit root tests of Augmented Dickey–Fuller (ADF), time series properties of the data are analyzed by F statistic (chow test) approach to determine structural breaks in variables of agricultural commodities. The result from the Chow test which was formalized from Perron[23] clearly indicate that on time series data on three assumed dates 1998-99, 2004-05 and 2006-07 at which there was a statistically significant structural break. The study reveals that endogenously determined structural break time for the agricultural variables (area, production, productivity) of Assam was found to be 1998-99, 2004-05 and 2006-07.

Key words: *Structural break, Assam, Rice, Production.*

INTRODUCTION

Agriculture and its allied activities played an important role in the socio- economic development of the State of Assam as this sector is the major contributor to the State economy as well as providing livelihood to a significant proportion of the population of the State. About 99 per cent area of total land mass of the State is rural and almost 50 per cent of the total land area is utilised for cultivation. The net cultivated area of the State is 28.10 lakh hectares (2008-09) and the per capita availability of net sown area comes to around 0.1 hectare. On the top of it, 23 per cent of the net sown area is either flood or draught prone. The average operational holding is 1.15 hectare only and more than 83 percent of the farmer family is small and marginal farmers [2005-06, Agricultural Census]. The contribution of the agriculture sector to the GSDP (at constant 2004-05 prices) was pegged at 4.1 per cent in 2009-10 (Quick estimate) recorded showing a growth from 2005-06 but remained lower over 2008-09.

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However, this sector continues to support more than 75 per cent population of the State directly or indirectly providing employment of more than 53 per cent of the workforce. *Structural break* concept is coming from econometrics. It appears when we see an unexpected change in a time series data. In general, this can lead to huge forecasting errors and unreliability of the model. Structural break tests help us to determine when and whether there is a significant change in our data. After critical analysis of the sectoral Growth of the State Economy it has been observed that the growth of the agriculture and allied sector was not encouraging during the last three consecutive Five-Year Plan [8th, 9th and 10th Five-Year Plan] periods. This depressing performance was continued even during the first year of 11th Five-Year Plan, but made some recovery over the average growth of the 10th Five Year Plan.

Most of the work has concentrated on detecting the presence of structural break(s) and estimating the location of the break(s). The method of estimation of the standard regression model, OLS (Ordinary Least Square) method, is based on the assumption that the means and variances of these variables being tested are constant over the time. Variables whose means and variances change over time are known as non-stationary or unit root variables. Therefore, incorporating non-stationary or unit root variables in estimating the regression equations using OLS method give misleading inferences. Instead, if variables are non-stationary, the estimation of long-run relationship between those variables should be based on the co integration method. Since the testing of the unit roots of a series is a precondition to the existence of co integration relationship, originally, the Augmented Dickey-Fuller[12] test was widely used to test for stationarity. However, there are two well-known problems with structural break estimation. The first one is the difficulty of differentiating data that is subject to a structural break (before and after which data shows stationary and trend stationary patterns) from data having a unit root. The second one is that although break locations in data can be estimated consistently, there is no efficiency condition for the limiting distribution of the estimates. Although consistency is a sufficient condition for the purpose of many empirical studies, efficiency could still be of interest if the aim is to obtain the smallest confidence intervals around the break dates. The stated reason behind these difficulties of estimating structural breaks is that the problem is nonstandard; a break date only appears under the alternative hypothesis, not under the null of no break. Perron[21] empirical study makes a comprehensive review of both problems; however it is very technical, and seemingly there is a lack of resources summarizing the relevant literatures. To overcome this, Perron proposed allowing for a known or exogenous structural break in the Augmented Dickey-Fuller (ADF) tests. In this paper, we study the structural break in rice from the year 1991 to 2015. From this data we see that the production of rice is increasing in the year 1999-2000 compared with the previous data and decreasing in the year 2004-2005 and 2006-2007 compared with the other years. The reason of this growth in the production of rice due to Agro-Climatic condition, improved farm mechanization and assured irrigation, use of quality certified seeds of HYV, popularizing the integrated Nutrient and Pest Management with the special use of bio-fertilizer and bio-pesticides and organic farming etc. Also the reason behind the declining growth in production of rice is due to the adverse weather condition weather, limitation of mechanization etc.

Keeping all these points in view in this paper Chow test has been employed to study the structural break in agricultural commodities (rice) in Assam. Here the structural break points have been detected using graphical method. In addition, as F test has been applied for testing stationary.

MATERIAL AND METHODS

A series of data can often contain a structural break, due to a change in to Agro-Climatic condition, farm mechanization and irrigation. The *F test (chow test)* is applied to test the existence of endogenously determined structural break time in these dates. In this case the first model specifies just a single regression line to fit the data points which can be expressed as:

$$log\, s_t = \alpha_0 + \alpha_1\, log\, x_t + \alpha_2\, log\, m_t + \alpha_3\, log y_t \quad + \mu_t \qquad (1)$$

wheres refers structural break, x , area, m , production, y , productivity, α's are unknown parameters to be estimated, t, is time in years (1991-2015) and μ is random terms that are independently and identically distributed with mean zero and variance^2 (σ^2). The model in effect determines whether a single regression is more efficient than three separate regressions involving splitting the data into three sub-samples, given as:

$$log\, s_t = \beta_1 + \beta_2\, log\, x_t + \mu_{1t}\,;$$
$$log\, s_t = \delta_1 + \delta_2\, log\, m_t + \mu_{2t}\,;\, and \qquad (2)$$
$$log\, s_t = \theta_1 + \theta_2\, log\, y_t + \mu_{3t}$$

Where, β's, δ's, θ's are unknown parameters to be estimated and μ is random terms that are independently and identically distributed with mean zero and variance^2 (σ^2). This suggests that model 1 applies before the break at time t, while model 2 applies after the structural break. If the parameters in the above three models are the same, that is, $\boldsymbol{\beta_1 = \delta_1 = \theta_1}$ and $\boldsymbol{\beta_2 = \delta_2 = \theta_2}$ then the three models can be expressed as a single model as in case 1, where there is a single regression line. The Chow test basically tests whether the single regression line or the three separate regression lines fit the data best.

Regressions were run for each of the assumed policy event date, 1998-99; 2004-05; and 2006-07. Then tests for a structural break involves testing whether the coefficients on $\boldsymbol{\beta_1 \log x_1}$, $\boldsymbol{\delta_2 \log m_1}$ *and* $\boldsymbol{\theta_3 \log y_1}$ are significantly different from zero. To estimate equation (2) the time-series approach was applied. The empirical results were tested using E views 9 and SPSS 20. The data used in the present study have been taken from the reports of Directorate of Economics and Statistics.

To test the hypothesis

H_0: There is no structural break versus H_1: There is a structural break, regression of RSS (regression using all the data, before and after the structural break), RSS_1 (regressions on the data before the structural break and RSS_2 (regressions on the data after the structural break) is done.

RESULTS AND DISCUSSION

1.1. Descriptive evidence:

The value of real Area, Production and Productivity data presented in Figure 1 indicates that the actual structural break date for the variables was *1998-99; 2004-05; and 2006-07.*

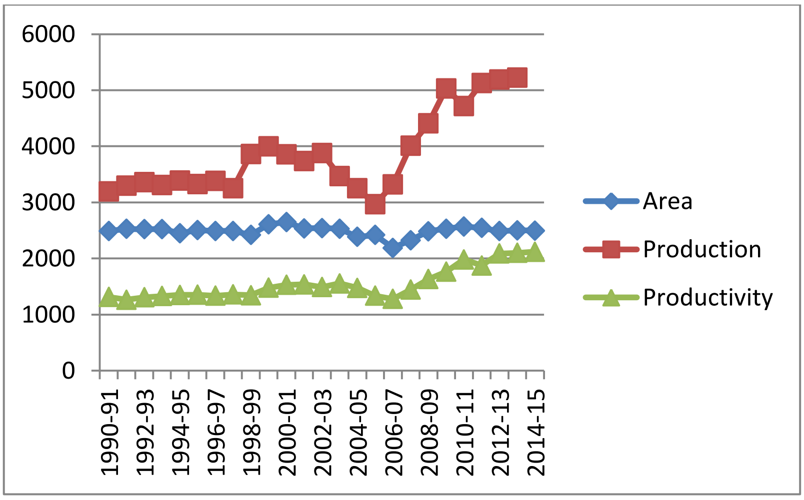

Fig. 1: Structural break time for area, production and productivity in Assam (1990-2015)

1.1. Empirical estimation

Two levels of analysis were presented. First, graphical analysis of time series is shown and explained. Secondly, results of econometric tests are given.

1.2. Graphical analysis

From the graphs it is probable that a structural break occurred in the year *1998-99; 2004-05; and 2006-07*. Conversely, graphical analysis is not conclusive; more credence is given to the econometric analysis that follows.

1.3. Results of econometric tests

The estimation begins with the testing of variables for unit roots to determine whether they can be considered as a stationary or non-stationary process. Table 1 presents the Augmented Dickey Fuller (ADF) tests of variables. The tests showed that the variable log *production* was stationary at first difference while the other variables were stationary at second difference. Critical values for tests in log area were found to be 3.788030 and 3.012363 at 1% and 5%. Critical values for tests in log production and productivity were found to be same. That is *3.752946 and 2.998064 at 1% and 5% respectively*. Tables gives details of unit root test outputs of variables.

To examine whether the integrated variables are co integrated, The concept of co integration implies that if there is a long-run relationship between two or more non-stationary variables, deviations from this long-run path are stationary. Johansen's[15,17,16] co integration multivariate procedure is used to establish whether the variables are co integrated in the long run. As result, the likelihood ratio indicates no co-integrating equations at 5% significance level. In other words, it rejects null hypothesis of having more than co-integrating vector. Since the test statistic (14.05730) is less than the 95% critical value (25.87211) of the likelihood ratio test, it is possible to reject the null hypothesis of more than one co-integrating vector (Tables 2). The maximum Eigen value test starts with the null hypothesis of at most r co integrating vector. The result for maximum Eigen value test confirms the rejection of the null hypothesis; that is, more than one co integrated vectors. Therefore, both maximum Eigen value and likelihood ratio indicate that there is no co-integrating equation at 5% significance levels (Table 2).

Table 1: ADF unit rot tests

Variables	ADF test statistics	Order of integration	Critical values at 1%	Critical values at 5%
Log area	-5.470852	I(2)	3.788030	3.012363
Log production	-4.073601	I(1)	3.752946	2.998064
Log productivity	-4.303333	I(2)	3.752946	2.998064

Table 2: Co-integration tests for log area and log productivity

Hypothesized no. of (CE)	Eigen Values	likelihood ratio	5% critical value	1% critical value
r=0	.363776	14.05730	25.87211	19.93711
r≤1	.146989	3.656608	12.51798	6.634897

Further, it was analyzed that a single regression line is not a good fit of the data due to the structural break in the year *1998-1999, 2004-2005 and 2006-2007*. This needs the residual sum of squares and Chow test which is a variation of the F-test expressed as:

Table 3: RSS (residual sum of squares) for all data

Model	Sum of Squares	Df	Mean Square	F	Sig.
Regression	1089.927	3	363.309	36.318	.000
Residual	210.073	21	10.003		
Total	1300.000	24			

Table 4: RSS (residual sum of squares) before structural break with break point 1998-99

Model	Sum of Squares	Df	Mean Square	F	Sig.
Regression	38.169	3	12.723	13.286	.015
Residual	3.831	4	.958		
Total	42.000	7			

Table 5: RSS (residual sum of squares) after structural break with break point 1998-99

Model	Sum of Squares	Df	Mean Square	F	Sig.
Regression	306.490	3	102.163	36.585	.000
Residual	33.510	12	2.792		
Total	340.000	15			

The statistic F is

$$F = \frac{RSS - (RSS_1 + RSS_2)K}{RSS_1 + RSS_2/(N_1 + N_2 - 2K)}$$

Where, RSS residual sum of squares of the model on all data; RSS_1 and RSS_2 sum of residual squares of the models on the two subset of data (before and after structural break time) respectively; and k number of restrictions (parameters to be estimated)

Based on these out puts the test statistic was calculated using the following formulae:

$$F = \frac{RSSR - (RSS_1 + RSS_2)K}{RSS_1 + RSS_2/(N_1 + N_2 - 2K)}$$

$$F = \frac{210.073 - (3.831 + 33.510)2}{3.831 + 33.510/(8 + 16 - 4)}$$

= 135.391/1.867

=72.517

The critical value for F (2, 21) is 2.51 at 5% significance level. This implies that the test statistic (72.517) is greater than the 95% critical value (2.51) of F-test; it is possible to reject the null of no structural break in rice under investigation. It was concluded that there is structural break in rice in the year 1998-1999. Moreover, analysis with chow test using F-test estimation technique indicates that there is structural break time for the variables under investigation. The Chow test results for area, production and productivity are follows (Table 10 – 12). Thus there was a structural break in the series in 1998-99 (Table 10).

Table 6: RSS (residual sum of squares) before structural break time with break point 2004-05

Model	Sum of Squares	Df	Mean Square	F	Sig.
Regression	198.004	3	66.001	22.376	.000
Residual	29.496	10	2.950		
Total	227.500	13			

Table 7: RSS (residual sum of squares) after structural break time with break point 2004-05

Model	Sum of Squares	Df	Mean Square	F	Sig.
Regression	79.050	3	26.350	45.821	.000
Residual	3.450	6	.575		
Total	82.500	9			

Based on these out puts the test statistic was calculated using the following formulae:

$$F = \frac{RSS - (RSS_1 + RSS_2)K}{RSS_1 + RSS_2/(N_1 + N_2 - 2K)}$$

$$F = \frac{210.073 - (29.496 + 3.450)2}{29.496 + 3.450/(14 + 10 - 4)}$$

= 144.181/1.6473

=87.525

The critical value for F (2, 21) is 2.51 at 5% significance level. This implies that the test statistic (87.525) is greater than the 95% critical value (2.51) of F-test; it is possible to reject the null of no structural break in rice under investigation. It was concluded that there is structural break in rice in the year 2004-2005. Moreover, analysis with chow test using F-test estimation technique indicates that there is structural break time for the variables under investigation in the Table 11

Table 8: RSS (residual sum of squares) before structural break time with break point 2006-07

Model	Sum of Squares	Df	Mean Square	F	Sig.
Regression	265.178	3	88.393	14.177	.000
Residual	74.822	12	6.235		
Total	340.000	15			

Table 9: RSS (residual sum of squares) after structural break time with break point 2006-07

Model	Sum of Squares	Df	Mean Square	F	Sig.
Regression	38.652	3	12.884	15.395	.012
Residual	3.348	4	.837		
Total	42.000	7			

Based on these out puts the test statistic was calculated using the following formula:

$$F = \frac{RSS - (RSS_1 + RSS_2)K}{RSS_1 + RSS_2/(N_1 + N_2 - 2K)}$$

$$F = \frac{210.073 - (74.822 + 3.348)2}{74.822 + 3.348/(16 + 8 - 4)}$$

= 53.733/3.9085

=13.7477

The critical value for F (2, 21) is 2.51 at 5% significance level. This implies that the test statistic (13.7477) is greater than the 95% critical value (2.51) of F-test; it is possible to reject the null of no structural break in rice under investigation. It was concluded that there is structural break in rice in the year 2006-2007. Moreover, analysis with chow test using F-test estimation technique indicates that there is structural break time for the variables under investigation in the Table 12

Table 10: Chow test on regression of Area, Production and productivity (1998-99)

F- statistic	7.966812	Probability	.0027
Log likelihood ratio	14.11500	Probability	.0009

Table 11: Chow test on regression of Area, Production and productivity (2004-05)

F- statistic	27.97216	Probability	.0000
Log likelihood ratio	32.46399	Probability	.0000

Table 12: Chow test on regression of Area, Production and productivity (2006-07)

F- statistic	39.96658	Probability	.0000
Log likelihood ratio	39.24840	Probability	.0000

CONCLUSION

This research examines the *structural break* points in rice for area, production and productivity in Assam using annual time series data spanning the years from 1990 through 2015. The structural changes occur during the sample period. Thus after applying unit root tests of Augmented Dickey–Fuller (ADF), time series properties of the data are analyzed by F statistic (chow test) approach to determine *structural breaks* in variables of agricultural commodities. The results from the Chow test clearly indicate that for all series under examination, the null hypothesis of no structural break points can be rejected. In other words, the empirical results based on the unit root tests as well as on the above model of unit root tests which take into account the presence of potential *structural breaks*, indicate that there is enough evidence to reject the null hypothesis of unit root for any of the variables under investigation.

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