On Convergence of the Growth Processes of Different Crops of Indian Agricultural Sector: Evidence from Structural Break Unit Root Test

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ABSTRACT *This paper applies a recent development in estimation and testing of Structural Break in econometric time series model, using unit root test to estimate the break point of the growth process for six different types of food crops and six different types of cash crops of Indian agricultural sector for the period from 1951-52 to 2013-14 by using recent time series econometric approach of endogenous structural break. The distinguishing feature of this method is that the break point is not dependent on the prior belief of the researcher, rather it is endogenously determined. An intercrop variation of the growth process is strongly evident. The growth processes of the eight among the twelve selected crops converge towards a positive deterministic trend forming a convergent group and showing more or less satisfactory performance of the agricultural sector. The study clearly identifies the crops whose performances are relatively poor and needs special attention.*

Keywords:

1. Introduction:

Indian agriculture is very much dependent on millions of peasant households, mostly having small land holdings with preponderance of owner cultivation. For the production and investment decisions of the farmers the government has little control but the government may control the legal, material and economic environment in which farmers work. At overall level, agricultural growth remained slow and which is around 3% in the country for many decades. Apart from that, agricultural growth may be confined to a few well advanced states and for this reason there may be some regional disparities (Vaidyanathan 1996).

The measurement of growth of agriculture production involves a number of issues like the choice of period, the selection of cut-off points for different sub-periods, estimation of growth parameters and proper interpretation of results. These points have been taken up in a number of studies made earlier (Srinivasan, 1979; Vidyyanathan, 1980; Sawant, 1983; Boyce, 1987; Saha and Swaminathan, 1994; Sawant and Achuthan, 1995; Bhalla and Singh, 1997, etc.).

Some literature deals with the application of the modern econometric time series analysis indicate that the growth process must have the statistical properties, and the break point of the series must be endogenously determined [(Mukhopadhyay and Sarkar 2001)); (Ghose and Pal 2007; (Sengupta, Ghosh and Pal 2009); (Pal and Ghose 2013); etc.]. However, a crop-wise study of the Indian agricultural sector using this modern time series approach is still lacking. The need for analyzing the cropwise study can be justified on the following ground.

The study on individual crops is extremely urgent because such study will highlight the crops for which the rate of growth production is satisfactory vis-a-vis the crops for which these performances are lacking. The study of the growth pattern of major crops and to find out the suitable break point on the growth process is essential given the changed scenario in Indian Agricultural Sector. Also it is needful to know whether this growth is stable or not.

The objectives of this study is to find out the suitable break point in the growth path of the production of major crops in Indian Agriculture and also to find out whether this growth is stable or not by using modern time series approach, for the period from 1951-52 to 2013-14. The output of Indian agricultural sector is divided into food crops and cash crops. The selected food and cash crops are as follows: **Food Crops:** Rice, Wheat, Maize (Corn), Jowar(Sorghum), Gram, Bajra(Peari Millets); **Cash Crops:** Cotton, Groundnuts, Jute, Rapeseed/Mustard Oil, Sugarcane, Tobacco.

The structure of the present paper is as follows: in **Section 2** presents the methodology of testing endogenous structural break by using Sen's (2003) approach in case of the rate of growth of production for the major crops in Indian Agriculture. Section 3 discusses the results of estimation. Some concluding remarks are made in the **section 4.**

2. Methodology and Data Sources:

2.1 Methodology:

In their path breaking paper Zivot and Andrews (1992) argued that exogenous structural break analysis for finding out the break point is not an appropriate method, because exogenous structural break analysis was based primarily on visual inspection of data. Zivot and Andrews argued that break point should be endogenously determined and can be evaluated considering following models:

$Y_t = a_1 + b_1 DU_t + c_1 t + d_1 Y_{t-1} + e_1 \Sigma\Delta Y_{t-1} + e_t$ .....Model A.....2.1

$Y_t = a_2 + g_2 DT_t + c_2 t + d_2 Y_{t-1} + e_2 \Sigma \Delta Y_{t-1} + e_t$ .....Model B.....2.2

$Y_t = a_3 + b_3 DU_t + c_3 t + g_3 DT_t + d_3 Y_{t-1} + e_3 \Sigma \Delta Y_{t-1} + e_t$ .....Model C.....2.3

Where

$DU_t = 1$ if $t > T\gamma$
$= 0$ otherwise

and

$DT_t = t - T\gamma$ if $t > T\gamma$
$= 0$ otherwise

Model A permits an endogenous break in the **level** of the series (also known as Crash Model), Model B allows an endogenous break in the **rate of growth** (known as Changing Growth Model) and Model C admits **both changes the level as well as growth (**also known as Mixed Model). If DT_t is positive (negative) and significant, then it is concluded that there has been an acceleration (deceleration) in the growth. Here T stands for total time period and γ stands for time break, i.e., $\gamma = T_B/T$. a_i, b_i, c_i, d_i, e_i, g_i are the parameters of the ith regression and T_B is the break point. One can estimate the above three regressions by OLS method and with the break fraction γ ranging from 2/T to T-1/T.

Sen (2003) argued that since the form of break is treated as unknown, the appropriate alternative should be the Mixed Model. Thus Sen (2003) considered only the Mixed Model which simultaneously allows for a break in the level as well as rate of growth and test for the existence of endogenous structural break [expression for Model C-equation (2.3)]. The test statistic used by Sen (2003) is SupWald statistic. It actually gives the joint null hypothesis of a Unit Root with no break in the intercept and the slope of the trend function. To calculate the maximum F-statistic for the null hypothesis, Sen (2003) applied the F-statistic in accordance with

$$F_T^{Max} = Max_{T_b \in \{[\lambda_0 T],[\lambda_0 T]+1,\ldots,T-[\lambda_0 T]\}} F_T(T_b)$$

Here T_B is the break point which is a constant fraction of the sample size T i.e. $T_B = \lambda^C T$ with the current break fraction $\lambda^C \in (0,1)$ and the smallest integer function.

Thus Sen (2003) suggested that after getting the maximum F-statistic amongst the alternative regression equations ranging from 2/T to T-1/T, the estimated F-statistic ($F_T^{\max}$) is compared with the asymptotic critical values of $F_T^{\max}$ given by Sen. Finally analyzing the nature of series, we can conclude whether the series follows TSP or DSP.

2.2 Data Sources:

All the data has been collected from the different issues of the Statistical abstract, Agriculture at a Glance, Agriculture in Brief, Handbook of Statistics of Indian Economics, Cost of Cultivation data published by the Government of India.

3. Results of Analysis:

The results of endogenous structural break by using Sen's (2003) approach are presented in the **Table 1, 2 and 3.** Now some interesting observations can be made from the mentioned Tables.

3.1 The case of Food Crops:

In case of Rice the suitable break point is 1988-89. The maximum F-statistic is statistically significant, implying that there exists a deterministic trend in the series. The coefficient of time is positive and statistically significant. It means that in case of Rice there exists a significant positive deterministic trend in the series. The nature of the series being trend stationary, the variance of the series is constant and independent of time. The coefficient of DT is negative and significant, implying that the rate of growth of Rice production decreases after the break. One of the main reasons of this deceleration may be that during

the second part of the late 80's non food grains output like milk, fishery, poultry, vegetables, fruits etc grows faster than the food grains.

In case of Wheat the suitable break point is 1967-68 but the maximum F statistic is statistically insignificant. Thus in case of Wheat, there exists a stochastic trend in the series. The coefficient of time is positive but insignificant. However, since the process is of DS type, no definite conclusion can be made on the rate of growth of production as well as the break point. Further as the coefficient of time is insignificant the variability of the series is inconclusive.

In case of Maize the maximum F statistic is statistically insignificant, implying that there exists a stochastic trend in the series and the corresponding break point is 1971-72. Not only that, the coefficient of time is positive and significant. So, one can conclude that the variability in the production of Maize increases over time. The coefficient of DT is negative and significant supporting the fact that the variability in the production process of Maize decreases after the break.

In case of Jower the underlying process is TS, implying the existence of a deterministic trend in the series and the corresponding break point is 1994-95. The coefficient of time is positive and significant. So, the production of Jower converges to a positive deterministic trend. As the nature of the series is TS type so one can conclude that the variance of the series is constant and independent of time.

In case of Gram the suitable break point is 2000-01. The maximum F-statistic is statistically significant, implying that there exists a deterministic trend in the series. The coefficient of DT is positive and statistically significant, showing that the rate of growth of Gram production increased significantly after 2000-01.

In case of Bajra 1974-75 is the suitable break point. Further the production of Bajra converges to a positive and deterministic trend as the underlying process is TS and the coefficient of time is positive and statistically significant explaining the fact that the rate of growth of Bajra production increased over time.

3.2 The case of Cash Crops:

In case of Cotton and Rapeseed/Mustard Oil the underlying series is DS type and the coefficient of time is positive and statistically significant implying that the variability in the production had increased over time. But as the process is of DS type, no definite conclusion can be made on the rate of growth of production as well as the break point.

In case of Jute the suitable break point is 1967-68 and the maximum F statistic is statistically significant, implying the production of Jute converges to a deterministic trend. The coefficient of time in case of Jute is positive and significant. Thus there exists a positive and significant deterministic trend in case of Jute. The coefficient of DT is negative and significant implying that the rate of growth of Jute production decreased after the break year 1967-68. One of the main reasons for this deceleration is that green revolution policies affects positively in the western side on India and more specifically in case of the production of food grains. As Jute production mainly concentrated in West Bengal and Assam the effect of green revolution was not affects positively rather negatively in case of Jute.

In case of Groundnuts, Sugarcane and Tobacco the suitable break points are 1999-2000, 1989-90 and 1999-2000 respectively. From the results of the analysis one can conclude that the production of Groundnuts, Sugarcane and Tobacco converge to a positive and deterministic trend as the underlying process is TS and the coefficient of time is positive and statistically significant implying that the rate of growth of production increased over time. Moreover as the underlying process is TS type the variance in the production is constant and independent of time.

4. Conclusion:

The study uses the data on the production of different food Crops and Cash Crops of Indian Agriculture for the period 1951-52 to 2013-14 and tested endogenous structural break in the series. The following conclusions emerge from the analysis:

- An intercrop variation of the growth performance is strongly evident.
- Depending on the growth performance the crops can be classified under the following groups:
  Group-A: this group consists of some of the food crops like Rice, Jower,
  Gram and Bajra and the cash crops like Jute,. Groundnuts, Sugarcane and Tobacco, the growth processes for which converge towards a significant and positive deterministic trend and these crops form a 'Convergent Group'. Since the underlying stochastic process of these crops corresponds to TS type, the extent of the variability of the series remains constant over time. The coefficient of time is positive and statistically significant for all these crops except Gram implying a significant increase in the rate of growth of these crops over the entire period of study. In case of Gram although there was an significant increase in the rate of growth after the break year 2000-01,

the coefficient of time is negative for the entire period. However the coefficient is not statistically significant. Thus all the crops except Gram under Group-A are better performer in the sense that growth process of these crops follow a significant positive deterministic trend with constant variability.

- Group-B this group consists of some of the food crops like Wheat and Maize and for some of the cash crops like Cotton and Rapeseed/Mustard Oil for which growth process follows there exists a stochastic trend, suggesting that no definite conclusion can be made on the nature of the growth process or about the break point of the series. Added to this the extent of variability of the crops has increased over time for crops like Maize, Cotton and Rapeseed/Mustard Oil as the coefficient of time is statistically significant and positive. So one can conclude that the performances of the crops under Group-B are relatively poor.

The cropwise study of Indian Agriculture by using modern time series techniques clearly identifies the crops whose performances are satisfactory vis-a vis and other crops showing relatively poor performance and hence needs special attention. However, positive thing to note is that the growth processes of the eight among the twelve selected crops converges towards a positive deterministic trend forming a convergent group, showing on the whole more or less satisfactory performance of the agricultural sector. One limitations of the study is that the reasons behind the emergence of break point of different crops are not properly been explored. Thus crops specific study concerning the major states who are the major producer of these crops is the agenda of our future research.

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Table 1
Maximum F-Statistics and corresponding break points for growth analysis.

Food Crops				**Cash Crops**			
	F-Statistics	**Break Point**	**Nature of Series**		**F-Statistics**	**Break Point**	**Nature of Series**
Rice	14.56255*	1988-89	TS	**Cotton**	5.8321	2000-01	DS
Wheat	4.49054	1967-68	DS	**Jute**	11.6608*	1965-66	TS
Maize	8.683673	1971-72	DS	**Sugarcane**	13.4279*	1989-90	TS
Jower	1526.254*	1994-95	TS	**Rapeseed/ Mustard Oil**	8.6814	1987-88	DS

Gram	9.77421**	2000-01	TS	**Groundnut**	14.1569*	1999-2000	TS
Bajra	17.2581*	1974-75	TS	**Tobacco**	12.18723*	1999-2000	TS

*** Significant at 1% level, ** Significant at 5% level, *** Significant at 10% level.**

Table 2

Estimate equation of growth by Amit Sen's approach for Food Crops

	Rice		Wheat		Maize		Jower		Gram		Bajra	
Variables	Coeff.	t-Stat.	Coeff.	t-Stat.	Coeff.	t-Stat.	Coeff.	t-Stat.	Coeff.	t-Stat.	Coeff.	t-Stat.
C	3.900	6.411*	2.805	1.247	0.745	5.504*	1.887	11.701*	3.978	4.465*	1.457	6.036*
DU	0.176	3.406*	2.530	1.444	-0.206	-2.619*	-0.209	-2.358*	-0.210	-0.321	-0.197	-1.519
TIME	0.030	6.003*	0.204	1.146	0.036	3.518*	0.005	1.924**	-0.007	-0.877	0.032	3.335*
DT	-0.014	-3.927*	0.476	1.774***	-0.011	-1.718***	-0.016	-1.473	0.230	2.025*	-0.009	-1.113
Y_{t-1}	-1.230	-6.324	-0.441	-2.748	-0.831	-4.738	-0.991	-64.388	-0.744	-4.341	-1.351	-6.109\

*** Significant at 1% level, ** Significant at 5% level, *** Significant at 10% level.**

Table 3

Estimate equation of growth by Amit Sen's approach for Cash Crops

	Cotton		Jute		Groundnuts		Rapeseed/Mustard Oil		Sugarcane		Tobacco	
Variables	Coeff.	t-Stat.	Coeff.	t-Stat.	Coeff.	t-Stat.	Coeff.	t-Stat.	Coeff.	t-Stat.	Coeff.	t-Stat.
C	1.23	4.60*	4.14	4.06*	1.54	5.24*	-0.20	-2.71*	31.76	3.66*	-1.60	-6.31*
DU	-0.28	-2.00*	-2.48	-3.24*	-0.34	-2.24*	0.42	3.62*	28.72	2.80*	-0.43	-4.26*
TIME	0.02	4.10*	0.35	3.60*	0.02	4.19*	0.03	4.63*	3.00	4.10*	0.02	5.96*
DT	0.10	3.55*	-0.19	-2.18*	0.00	-0.16	-0.01	-2.41*	-0.31	-0.51	0.01	0.98
Y_{t-1}	-0.94	-4.45	-1.28	-6.37	-1.15	-5.10	-0.83	-4.86	-0.75	-4.18	-1.16	-6.57

*** Significant at 1% level, ** Significant at 5% level, *** Significant at 10% level.**