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Growth and Fluctuations in Productivity in Total Foodgrain in India during 1950-51 To 2009-10

Debasish Mondal
Professor,
Deptt.of Economics with Rural Development,
Vidyasagar University,
Midnapore

Swarup De
Faculty
Department of Commerce,
Jhargram Raj College,
Jhargram

Abstract

The present paper makes an attempt to estimate the nature of growth, break and fluctuation in productivity in total foodgrains in all India in the period 1950-51 to 2009-10. Breaks in the growth paths have been evaluated by the modified Bai-Perron methodology and fluctuations around the growth path have been decomposed into year to year fluctuation and cyclical fluctuation by using modified Cuddy-Della Valle and modified Coppock methodologies. The entire research work is based on secondary data of productivity in total foodgrain in India collected from "Directorate of Economics and Statistics", Ministry of Agriculture, and different issues of Statistical Abstract, Govt. of India. From the analysis it is observed that there are three breaks in the growth path: First, in late 60s (initial phase of green revolution) with no significant change in growth rate; second, in late 70s (later phase of the green revolution) with a significant increase in growth rate and third, in early 90s (new economic policy) with a significant fall in growth rate. Fluctuation from growth path has decreased in the later phase of green revolution technology and it has again increased in the era of liberalization (new economic policy regime) but year to year fluctuations have increased in the era of green revolution as well as in the new economic policy regime.

Keywords: Growth, Breaks, Fluctuations, Productivity, Foodgrain

Introduction

After 65 years of independence Indian economy is still an agrarian economy. Agriculture is described as the backbone of Indian economy, because agriculture provides livelihood to 65 to 70 percent of the total population. This sector also provides employment to 52 percent of countries work force and it is the single largest private sector occupation. Although agriculture has got a prime role in Indian economy but the share of agriculture in national income has come down since inception of planning era in the economy. The contributory share of agriculture in Gross Domestic Product was 55.4 percent in 1950-51, 52 percent 1960-61 and is reduced to only 14.6 percent in 2009-10.

Aim of the Study

The present paper makes an attempt to estimate the breaks in the growth path of productivity in total foodgrain for the whole period and also tries to estimate the growth rates in productivity in total foodgrain in the different regimes and for the whole period also examine whether there is any significant difference or not in the productivity in total foodgrain in between regimes. In this paper, we try also to estimate the nature and extent of fluctuation in productivity in total foodgrain in different regimes and for the whole period in all India and examine how the length of cycle in productivity in total foodgrain has changed over different regimes in all-India. Fluctuations around the growth path have been decomposed into year to year fluctuation and cyclical fluctuation by using modified Cuddy-Della Valle and modified Coppock methodologies.

In this work, we use time series data on productivity in total foodgrain from 1950-51 to 2009-10 and to identify breaks in the data series. We have developed our methodology in such a way that if significant breaks are present in the data series, then that will automatically be incorporated in our method.

Review of Literature

The nature of growth and fluctuation in Indian agriculture has been a debatable issue both at the states and the national level. Boyce has shown that the approach for the measurement of sub-period growth rates used so far suffers from "discontinuity bias". To overcome this difficulty Boyce has introduced a new approach in which "kinked exponential model" is fitted for estimating sub-period growth rates. D. Mondal and S. De concluded that the growth of productivity of total foodgrain has significantly decreased after the adoption of new economic policy in India and they also observed that in the recent years (2003-04 to 2009-10) growth of productivity of total foodgrain has significantly increased. Mehra et al. (1981) made an attempt to examine the effect of new seed fertility technology in Indian agriculture. The study compared variability in production across crops and regions in India during the period of 1949-50 to 1964-65 and 1964-65 to 1978-79 to find the change in instability in agriculture before and after the introduction of green revolution technologies. Mehra, Shakuntala (1981) found about instability in Indian agriculture. The standard division of production of all crops as well as foodgrain increased by 75% and 65% respectively during the period 1967-68 to 1977-78. Singh (1981) observed that in most of the states of India rice was the main cereal crop and he found that in this crop the growth rate had not been uniform in the different states. Sibaji Chakrabarti (1982) made an attempt to study the growth pattern of foodgrains production and of agriculture as a whole in India. He finally concluded, all that had been achieved through technological breakthrough in the field of foodgrains production such as the green revolution program, is that we have regained the growth pattern that was prevailing prior to the stagnancy period (segment-II)- i.e., prior to 1958-59. Ray SK (1983a) concluded that the growth and instability in Indian agriculture for the period of 1950-80. Ray concluded that the environment for production in under human control the use may achieved higher growth and stability. Ray (1991) concluded that the production instability and consequence of rapid agricultural growth and there is little that can efficiently be done about it. Praduman Kumar and Surabhi Mittal (2006) in their article made an attempt to study "Agricultural productivity Trends in India: Sustainability Issues". They observed that in the post-green revolution period the total factor productivity growth was decelerating in case of agriculture in India. Hazell (1982) used the same data set that was used by the Mehta (1981), Hazell made an attempt to calculate the "Instability in India foodgrain production" and found that during the period of 1967-68 to 1977-78, when measured around the trend line the co-efficient of variation of total cereal production was 5.85% and this was nearly 50% larger than the co-efficient of variation during the period 1954-55 to 1964-65, they also observed that the fluctuation arose due to the substantial price instability. According to Chand and Raju (2008), despite progress in irrigation and other infrastructural developments in agriculture, the instability in agricultural production has shown an increase after early- 1990s in the major crops grown in Andhra Pradesh. In contrast, farm harvest prices of groundnut and cotton have shown a decline in instability during 1993-2004, than during 1981-1993. Chand and Raju (2011) observed that the yield variability in foodgrain as well as in non-foodgrain crops has been observed much lower in the first phase of green revolution, extending up to 1988 as compared to pre-green revolution period. Deviation in yield, away from the trend, has witnessed further decline during 1989-2007. R. Mahadevan (2003) evaluated the productivity growth in Indian agriculture the ratio of Globalization and Economic reform. It analyses the effects on agricultural productivity and growth and discusses the problems and prospect for globalization to draw policy implications for the future of Indian agriculture. It was observed that India has shown commitment to stay on the bandwagon of globalization. Larson et al., (2004) concluded that in the later phase of green revolution period where the technology spread in almost every states of India then the instability in yield and production of foodgrain was increased.

Methodology

Growth in a time series Y_t is usually estimated by the semi-log-linear trend regression $\ln Y_t = a + bt$ with b as the assumed constant exponential rate of growth ('ln' stands for natural logarithm). Under the assumption of constant rate of growth, fluctuations around the growth path are explained to be constituted by variability of growth normally modelled through breaks and shifts in growth paths arising from policy changes, cyclical fluctuations, irregular fluctuations including spikes due to sudden and massive changes and all sorts of other disturbances in Y_t. If the period under consideration consists of more than one policy regime it has become conventional either to fit separate regressions for different sub-periods (policy regimes) or to use single regression with dummies for different sub-periods or to fit a kink linear trend line for $\ln Y_t$ with kinks at the points of policy changes by using single regression with dummies for different sub-periods with restriction for kink (Boyce, 1987). If there exist some breaks or kinks in the growth path but are ignored and a constant growth is estimated, growth rates will be underestimated for some regimes and overestimated for others, and fluctuation will be unduly large.

Kink linear regression model as explained above fails to be completely meaningful when growth path in any sub-period in place of swinging up or down only, shifts up or down with or without any such swing. For majority of macroeconomic series policy changes create both these movements in growth paths. A possible reason behind this is that the policy change that is taking place in any period faces a setback in the first (or first two) years and then it leads to a new growth path. In this case, two kinks in place of one kink for each policy change (one at the starting year of the new policy regime and the second at a later year from which the true growth path in the new policy regime starts taking its shape) may be more relevant in comparison to (i) single regression without dummies, or (ii) single regression with dummies and with restrictions for a single kink at each change in policy regime and even in comparison to (iii) separate regression, or (iv) single regression with dummies but without any restriction for kink(s). The regression used in such case can be named double kink linear regression in contrast to the name kink linear regression used frequently in the time series analysis of growth and fluctuation.

A double kink linear path may also be caused by the failure of the policy in the first regime that forces the authority to undertake a new policy leading to the second regime. Sudden short term changes created by external factors, which has nothing to do with policy regimes, may also be accommodated by more than one kink in between two trend growth paths. A double kink linear path actually consists of two regimes but three sub-periods, the middle sub-period is of small duration of 1 to 2 years producing the double kink in between two regimes.

Sudden short term changes normally create spikes and can be accommodated by three kinks and the kink linear model is needed to be modified further. A triple kink linear path consisting of two regimes actually contains four sub-periods, the middle two sub-periods are of small duration of 1 to 2 years each producing the triple kink in between two regimes.

Identifying Optimum Breaks

To identify optimum breaks in a data series we try to fit a kink linear path to the series that gives us the best fit under the assumption that there may be as many breaks as possible. The best fitted path may be chosen through maximisation of adjusted r-square or Scwartz Information Criterion (SIC) or Akaike Information Criterion (AIC) or minimisation of Bayesian Information Criterion (BIC). If adjusted r-square is used as the criterion, the algorithm for identifying optimum breaks in a macro series will be as follows. For a series of T years if we assume only one regime we regress $\ln Y_t$ on t. This gives us a r-square and an adjusted r-square slightly less than r-square because the degree of freedom of the model is T-2, only 2 less than T. If there exists fluctuations in the data series the value of r-square will be less than 1 and inclusion of a new variable J_2 along with t (= J_1) in the J-model mentioned above (or, inclusion of a kink or break in the model) will raise r-square. This increase in r-square may not imply a better fit because at the same time it will reduce the degree of freedom of the model to T-3 and r-square will be adjusted at a greater rate. This new adjusted r-square may not be greater than that in the first model. As the kink can be chosen in any one of the T-2 interim years there will be T-2 alternative possibilities and r-square will increase differently. To check whether adjusted r-square is increasing we shall check only that possibility for which increase in r-square is largest. If the value of r-square in that possibility is still less than 1 we can include a third variable J_3 along with J_2 and t (= J_1) (or we can include 2 kinks or breaks) and this will raise r-square further. Whether this gives a further better fit or not can be judged by increase in adjusted r-square. The process will be continued in this way to accommodate as many breaks as possible and to reach the situation that maximises adjusted r-square. For a series of T years we can accommodate a maximum of T-2 breaks with T-1 sub-periods, each starting in one year and ending in the next year. In this case, the fitted path coincides perfectly with the observed path and even if the degree of freedom falls down to zero, both r-square and adjusted r-square become 1. However, this is not the best fitted path because it reduces the degree of freedom to zero. This is one of the reasons why Bai and Perron (1998, 2003) propose to choose the path that minimises BIC. This criterion puts an increasing penalty for the reduction in degrees of freedom. This leads to some sub-periods lasting for some years and can be called a regime. This may also lead to multiple breaks, not only single, double or triple breaks, in between any two regimes. To avoid this latter phenomenon we restrict ourselves only to those paths for which there are only single, double or triple breaks in between any two regimes, otherwise, the path becomes difficult to interpret. For convenience of calculations we shall also assume, following Bai and Perron (1998, 2003), a minimum duration of a regime and the possibility of a single, double or triple kink in between two regimes of 1 or 2 years each.

In each regime there may be cyclical, irregular or other fluctuations and so duration of a regime cannot be very small. It can be assumed to be of 8 to 12 years. Thus, if we have a series of 60 years (as is the case in the present context) and if we assume the minimum duration of a regime to be of 10 years, we can have a maximum of 6 regimes, each of exactly 10 years duration with no scope for double or triple kink in between two regimes. If there are 5 regimes, scopes for double or triple kink in between two regimes will be there; also there will be scope for some regimes lasting for more than 10 years. If there are 4 regimes, scopes for double or triple kink, or that for regimes longer than 10 years will increase further. Thus, to identify optimum breaks in a data series of 60 years with minimum duration of a regime to be of 10 years, we search for minimum BIC in all possibilities containing 1, 2, 3, 4, 5 or 6 regimes and single, double or triple kink of 1 to 2 years each in between any two regimes.

We propose a final modification to the model by allowing minimum duration of the regimes at the two ends to be of less than 10 years, because these two regimes may be truncated ones. We propose to take them at most half of 10 years or 5 years. This again leads to the possibility of 7 regimes at the maximum. It is nearly impossible to perform all these calculations even by using multiple regression programmes available in different statistical packages. We have to develop our own programmes independently or within the existing packages to reach our desired results. In the following sections we shall use these methods of identifying optimum breaks in Productivity in total foodgrain in India in the period from 1950-51 to 2009-10.

In case of measurement of fluctuation in a time series X_t, fluctuation is frequently interpreted in terms of fluctuation around the trend line. Fluctuation around the trend is generally estimated by the deviation of observed values from the estimated values in the regression mentioned above and it is denoted by e_t. The fluctuation index is obtained through the residuals sum square (RSS) $=\Sigma\, e_t^{\,2}$ in the following way.

$$I_{RSS} = \sqrt{\frac{1}{T}\sum e_t^2} \;/\; \overline{lnX}_t.$$

The numerator of the above expression is the SD of e_t and the denominator is the mean of $\ln X_t$. It is a measure very close to coefficient of variation of e_t multiplied by the square root of $(1-R^2)$ as proposed by Cuddy-Della Valle (1978).

Coppock (1962) has advocated an important methodology of measurement of fluctuation in a time series X_t. Coppock measurement of the index of fluctuation is given by $I_{coppock} = \mathrm{Exp}(SD(\ln(\frac{Xt+1}{Xt})))$, this measurement is based on year to year fluctuation. Now, in case of comparison between the two above mention methods, we face a problem. The RSS base measure has a zero lower limit and it can go beyond one – actually it has no upper limit. The coppock measure has a lower limit at one and it has no upper limit.

To overcome this difficulty, Mondal and Mondal Saha (2008) have proposed some adjustment to the above measures. The adjusted Coppock measure of fluctuation is given by $I_{coppock}' = \frac{SD\,(\ln(\frac{Xt+1}{Xt}))}{2\,(\overline{lnX}\,t)}$. This index is comparable to the RSS base index. The length of cyclical fluctuation can be calculated by squaring the value of the ratio of residuals base index divided by adjusted coppock index and then it is multiplied by 2.

In this paper we use the data set of productivity of total foodgrain from 1950-51 to 2009-10, for all-India level. Some researchers in this area use same data set and take breaks arbitrarily or at the dates of policy changes (for example, introduction of green revolution, introduction of new economic policy etc.) without examining whether they are able to produce significant breaks at those points or not.

In India, with the help of modified Bai-perron methodology, full period (1950-51 to 2009-10) has been divided into four regimes: regime – I (1950-51 to 1964-65), regime – II (1967-68 to 1979-80), regime – III (1979-80 to 1993-94) and regime –IV (1993-94 to 2009-10).

Result and Discussion

Basic results on growth in productivity in total foodgrain in India are presented in table –I. From table-I, it is observed that the growth rate in productivity in total foodgrain during the first regime i.e. in the pre green revolution regime was 2.09 per cent and it was highly significant. After the adoption of green revolution technology in Indian agriculture i.e. after mid 60's the growth rate in productivity in total foodgrain was decreased marginally and this fall was significant. Actually, after the adoption of green revolution technology in India, Initially this technology was not spread properly all over the country, it spread only few states of India.

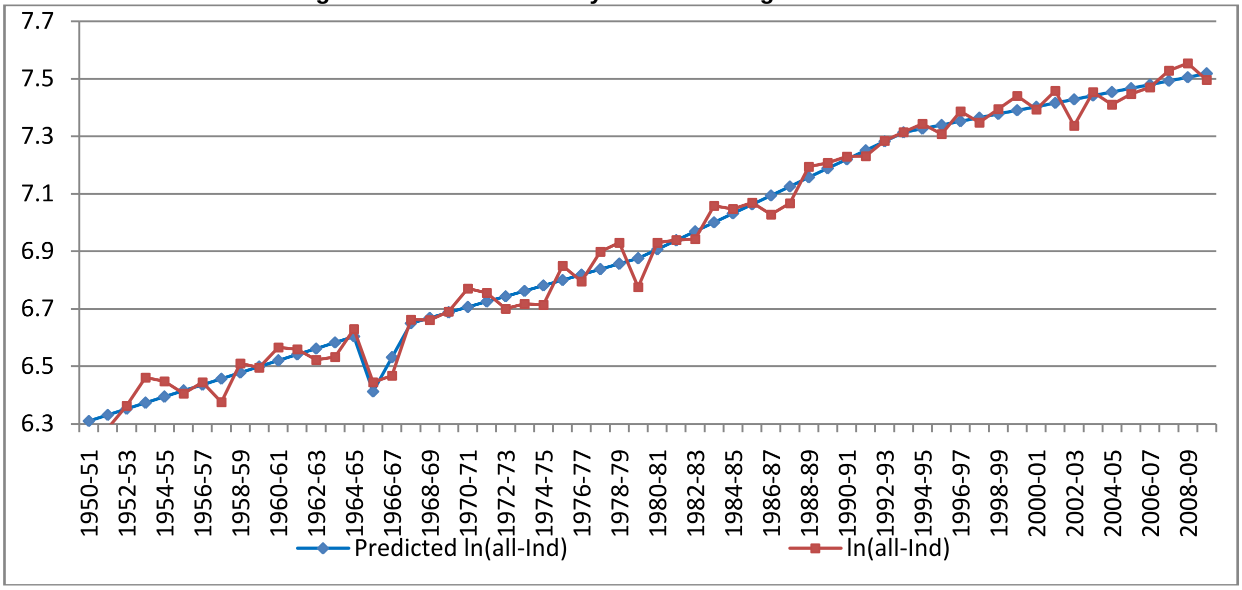
Table-I: Growth in Productivity in Total Foodgrain for All India

All India			
Periods	**Growth Rates (%)**	***T-Value***	***P-Value***
Full period (1950-51 to 2009-10)	2.21	46.71	1.01E-47
Regime – I (1950-51 to 1964-65)	2.09	7.73	2.95E-10
Regime – II (1967-68 to 1979-80)	1.88	7.09	3.29E-09
Regime – III (1979-80 to 1993-94)	3.13	16.71	8.85E-23
Regime – IV (1993-94 to 2009-10)	1.27	6.85	7.59E-09

Difference between Regimes growth rates (all India)			
Difference	GROWTH RATES (%)	***T-VALUE***	*P-VALUE*
Difference between Regime-I & II	-0.22	-0.57	0.5662
Difference between Regime-II &III	1.25	3.06	0.0033
Difference between Regime-III &IV	-1.85	-5.52	1.03E-06

In the later phase of green revolution technology i.e. in the third regime the growth rate in productivity was significantly increased by 1.25 per cent. The difference between two regimes (regime-II and regime-III) growth rate was also significant, actually in the later phase of green revolution, the technology was spread properly all over the states of India. In case of regime-IV i.e. after the adoption of new 1991 economic policy in India, the growth rate in productivity in total foodgrain was significantly decreased in larger percentage (1.85%) and the difference between this regime and previous regime growth rate was highly significant. The new economic policy was mainly adopted for the industrial sector; the agriculture sector was totally neglected during the policy regime.

Fig: Growth in Productivity in Total Foodgrain for All India



The fluctuations in productivity in total foodgrain at all India level was represented in table-II, in case of fluctuation analysis, the fluctuation in total variation in productivity in total foodgrain for the whole period arose mainly due to four types of fluctuation – year to year fluctuation, break in trend, cyclical fluctuation or irregular fluctuation. During this full period the fluctuation in total variation was only 16 per cent, and out of this fluctuation year to year fluctuation was less than 50 per cent, so more than 50 per cent fluctuation arose due to other three types of fluctuation. Now after the adoption of green revolution technology in India, the productivity in total foodgrain was more unstable as compared to the pre green revolution regime, because fluctuation from the trend in productivity was increased by 18.64 per cent during the regime-II from regime-I. During this regime cycles in the productivity in total foodgrain occurred more frequently than the previous regime, because the length of the cycle was decreased during this regime as compared to the previous regime. Now, in case of regime-III i.e. in later phase of the green revolution technology the productivity in total foodgrain was very much stable as compared to the previous regimes. The cycles in productivity also occurred less frequently compared to the previous regime, because the length of the cycle was greater than previous regime. Now, after the adoption of new economic policy in India, the productivity in total foodgrain was more unstable as compared to the previous regime, because the fluctuation from trend was larger than the previous regime (fluctuation from trend increased from 28 % to 51 %) and during this regime the cycles in the productivity in total foodgrain occurred more frequently as compared to the previous regimes

Table-II: Nature and extent of fluctuation in productivity in total foodgrain for all India

All India			
Regimes	**Year to year fluctuation**	**Fluctuation from trend**	**Length of Cycle**
Full Period (1950-51 to 2009-10)	0.0051(56.68%)	0.0090(16.09%)	6.22
Regime – I (1950-51 to 1964-65)	0.0045(65.46%)	0.0070(44.72%)	4.66
Regime – II (1967-68 to 1979-80)	0.0055(70.98%)	0.0081(63.36%)	3.97
Regime – III (1979-80 to 1993-94)	0.0038(67.44%)	0.0057(27.76%)	4.40
Regime – IV (1993-94 to 2009-10)	0.0040(82.66%)	0.0049(51.37%)	2.93

Conclusion

After the adoption of the green revolution technology in India, initially the growth rate in productivity in total foodgrain decreased significantly by 22 per cent and during this regime the productivity in total foodgrain was more unstable as compared to the pre green revolution regime. In the later phase of green revolution technology the growth rate in productivity in total good grain was significantly increased (increased by 1.25 per cent) and during this regime the productivity in total foodgrain was very much stable as compared to the previous two regimes. After the adoption of new economic policy in India, the growth rate in productivity in total foodgrain significantly decreased and the fluctuation from the growth path increased in larger percentage, so the productivity in total foodgrain was more unstable during this regime compared to the previous regime.

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