International Journal of Food and Agricultural Economics
ISSN 2147-8988, E-ISSN: 2149-3766
Vol. 7, No. 3, 2019, pp. 229-241

CONVERGENCE OF FOODGRAINS PRODUCTIVITY IN INDIAN AGRICULTURE

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Abstract

This study investigates the convergence hypothesis in productivity of foodgrains in terms of output per unit of cropped area during the period 2000-01 to 2012-13 across the major 18 foodgrains producing states of India using the two standard measures of convergence viz., sigma convergence and beta convergence. This has been done by applying the advanced panel data methodology, namely, panel unit root tests on demeaned series, static panel regression and dynamic panel regression apart from conventional measures based on standard deviation and coefficient of variation. A cross section regression shows irrigated cropped area to be the only significant explanatory variable for explaining productivity variation across the states. All the tests show evidence in favour of sigma and both conditional and unconditional beta convergences. This study with foodgrains productivity shows convergence or divergence in outcome(s) only. But convergence in means (i.e., sources) is also an important issue in this context. In this paper, we have also examined this in terms of input cost for two principal crops viz., paddy and wheat in the major foodgrains producing states. This has been studied by sigma convergence technique only. Results show convergence in average cost of production of wheat only, and not of paddy. This finding is important in explaining the role of technological spillover on input cost reduction across the states, and its effect in achieving convergence in foodgrains productivity.

Keywords: Productivity, Sigma Convergence, Beta Convergence, Panel Unit Root, Technical Spill Over.
JEL Codes:*Q1, Q18, C23, O47*

1. Introduction

Agricultural growth has a pivotal role to play in contributing to an economy's development, especially to a developing country like India. In fact, it is well accepted that agricultural growth is central to development (Gollin *et al*.(2002)). A consistent growth of this sector is vital for India to meet the challenges of food and nutritional security (WWF Report 2010). Agriculture sustains not only economic but also social, civil, cultural and environmental goals. In the context of Asia, researchers have concluded that in most of Asia, agricultural growth has tended to be much pro-poor compared to growth in the modern industrial or service sector (see, for example, Timmer(2005)). There are two sources of growth in production of a crop - one is growth in yield i.e., output per unit of area cropped and the other is growth in cropped area itself. As per the Agricultural Statistics 2013 of the Government of India, average growth rate in foodgrains production in India during 2007- 08 to 2012-13 was 3.1% whereas the average growth of cropped area and the average growth rate of yield were 0.3% and 2.7%, respectively, during the same period. It is thus evident that in recent times the major source of growth in foodgrains production has been the growth in productivity.

The modern literature on productivity convergence in agriculture has its root as far back as 1776 when Adam Smith wrote about the problem of lower productivity in agriculture compared to manufacturing as a consequence of inherent impossibility of complete division of labour in agriculture. The notion of slow productivity of agriculture has remained a central issue in many theories of economic development including the well-known dual economy model of Lewis(1954).Subsequent theories based on dual economy model such as the one by Prebisch(1984) imply both low productivity growth and a lack of convergence in productivity growth between developed and developing countries. However, contrary to this general belief that productivity grows less rapidly in agriculture sector than in manufacturing sector, Hayami and Ruttan (1985) examined a number of successful cases of rapid technological change in agriculture, and demonstrated the importance of institutions and policies in modern science-based agricultural development. Further, Martin and Mitra(2001)) found strong evidence of a rapid convergence in levels and growth rates of total factor productivity (TFP) in agriculture, indicating relatively rapid transfer of technological innovations and knowledge from one country to another. Several other studies like Rezitis (2005, 2010), Mukherjee and Kuroda (2003), and Ball, Hallahan, and Nehring (2004)have looked at the issue of convergence in agricultural productivity. Rezitis(2005) applied the wide spectrum of unit root tests for studying convergence in agricultural TFP among nine European countries and the USA for the period 1973-1993, and supported the presence of convergence among these countries. Mukherjee and Kuroda(2003) explored the question of convergence in TFP in agriculture across fourteen major agricultural states of lndia using the data covering the period 1973-1993, and found evidence of sigma convergence and conditional beta convergence.

In recent times, some studies have been carried out on convergence analysis of TFP in agriculture for member countries of the European Union following panel unit root test (see, for instance, Kizek et al. (2019)).In an important study, Poudel et al. (2011) tested agricultural productivity convergence in the United States using the state level TFP data, and found evidence of TFP convergence at the regional level for some regions/clusters. But hardly any of these studies on convergence in agriculture have applied a comprehensive time series based econometric methodology including dynamic panel model in their papers.

Like many other developing countries, Indian agriculture is also at a crossroad. Technology-based revolution in agriculture has significantly increased productivity/yield in major foodgrains items, especially, wheat and rice, in some parts of the country. However, with the passage of time, technology spillover and research and development spillover are expected to have touched the other parts of the country and other items of foodgrains as well. It is also relevant to note, in this context, that the world is focusing on productivity growth to fuel agricultural growth (Barrios and Nalica (1997)). It would, therefore, be worthwhile and interesting to investigate if there is evidence of convergence amongst the major foodgrains producing states of India in foodgrains productivity.

Although India was the second largest producer of both rice and wheat in the world in 2010, the productivity of each of these two major cereals in India was still lower than those of the top producers. For example, in case of rice, according to the FAO statistical year book 2013, the average productivity of India in 2010 was 3400 kg/hectare compared to the world average of 4300 kg/hectare. The same conclusion can be drawn for total cereals as well. However, in case of wheat the all- India productivity of 2800 kg/hectare is close to the world average of 3000 kg/hectare in 2010 with Punjab and Haryana having much higher productivity than the world average. Despite widespread presence of disparity in productivity among the Indian states, low productivity states like Rajasthan, West Bengal, Madhya Pradesh are now having higher productivity growth compared to high productivity states like Punjab and

Haryana. This evidence suggests that a study on convergence in productivity across Indian states would be relevant and useful for policy formulation. This is all the more so because new economic geography and endogenous growth theory suggest that the phenomenon of productivity convergence can be explained in terms of the spillover effect and technological diffusion (Paraguas and Dey (2006)).

One of the major consequences of 'Green Revolution' in the Indian agriculture during the 1960s and 1970s was an increase in inter-state disparity in development and income since only some selected states were able to adopt the new technology well endowed with irrigation whereas the other states suffered from stagnancy or poor growth (Chand and Chauhan (1999)). In order to address this problem, special efforts were given for the dry rain fed ecological regions in the form of adoption of new crop varieties, technology diffusion and enterprises, causing higher growth and productivity in the low productivity under-developed parts of the country , particularly the eastern part of the country during the 1980s and early 1990s (see, for details, Sawant and Achutan (1995) and Bhalla and Singh (1997)). Very few attempts have been made so far to look into the inter-state variations over time in the performance of Indian agriculture in the post- 'Green Revolution' era (Bhide *et al*.(1998) and Ghosh *et al*. (1998). It is also a fact that the number of studies on productivity convergence in Indian agriculture is indeed very few (see, in this context, Mukherjee and Kuroda (2003), and Somasekharan *et al*. (2011)).

The issue of convergence in productivity of foodgrains across Indian states is also important from the point view of impacts of climate change on Indian agriculture. The Word Wildlife Fund (WWF) Report-2010 indicates spatial and temporal variations for changes in temperature and rainfall, based on a simulation analysis of future climate scenarios in 11 districts of the Upper Ganga River Basin. The climate change has also been projected to cause adverse effects on the crop production in India. This study has also projected varied impacts on growth and yield of rice and wheat due to climate change.

The basic objective of this paper is to study the convergence in productivity of total foodgrains across the major foodgrains producing states of India during the period 2000-01 to 2012-13, by applying the modern econometric methodology available for panel data analysis. In order to address this empirical question of productivity convergence, we have used the two measures of convergence, namely, sigma convergence (σ- convergence) and beta convergence (β -convergence) that are commonly used in such analyses. For testing the sigma convergence, we have estimated the time trend in the values of each of standard deviation and coefficient of variation computed for the cross sectional logarithm (natural) series of productivity, the data for which are obtained in terms of output per unit of cropped area. We have, thereafter, examined the presence of beta convergence by using the standard panel unit root tests of the demeaned productivity series in logarithm. Further, in order to understand the dynamics of adjustment in convergence hypothesis, we have applied the generalized method of moments (GMM) of estimation of dynamic panel models based on first differenced values as also the system GMM.

The convergence on foodgrains productivity discussed above essentially captures convergence or divergence in outcome(s) only. But an important issue in this context is the convergence on means (i.e., sources). This obviously explains the causes of convergence or divergence in the outcome which is foodgrains productivity in this study. In this paper, we have , therefore, examined the issue of convergence/divergence in input cost for some principal crops in the major foodgrains producing states. This has been studied by sigma convergence technique only. These results should be important in explaining the role of technical spillover on input cost reduction which, in turn, would explain reasons for convergence in foodgrains productivity.

Based on such analyses, if a conclusive finding on convergence in foodgrains productivity is obtained, then apart from inter-state agricultural policy issues concerning foodgrains, this empirical result should be useful for solution to the major problem of finding surplus agricultural land required for rapid industrialization in an important emerging economy like India. Such a study would also show how far the ‘catching up’ hypothesis across the states of India holds in the context of productivity race in Indian agriculture. This paper has been organized as follows. The next section deals with data and methodology. Empirical results are discussed in Section 3. Summary and conclusions are given in Section 4.

2.Data and Methodology

2.1 Data

The data on yield (also called productivity) (unit: kg. / hectare) defined as output per unit of cropped area for total foodgrains for the major states of India during 2000-01 to 2012-13, have been collected from the Agricultural Statistics 2011 and 2013 of Directorate of Economics and Statistics under the Department of Agriculture and Cooperation of the Government of India. Considering the average share of foodgrains during this period, we have chosen 18 states for this study. Since in agricultural production irrigation is very important, we have taken irrigated area (in percentage) as the major explanatory variable. The time series for this variable is available at www.indiastat.com for the period 2001-02 to 2011-12 only. The other state-specific factor which is important from consideration of productivity is state-wise average operational holdings by major farm size groups, and this series has been taken from Rural Development Statistics 2011.

The data on state-wise credit share in agriculture has been obtained from state-wise Agricultural credit share in terms of primary agricultural credit society (PACS) loans issued in 2005-06 and published by the EPW research foundation 2007-08. The data on cost of production in Rs. per quintal for paddy and wheat for selected states have been collected from www.indiastat.com for the period 2005-06 to 2007-08.

2.2 Methodology

Two concepts of convergence hypothesis, namely, sigma convergence and beta convergence, exist in the literature. In the context of foodgrains productivity , sigma convergence occurs when cross sectional dispersion measured by the standard deviation and/or coefficient of variation of the logarithm of foodgrains productivity across the Indian states tends to decline over time. This can be verified by running a regression of either or both of the cross sectional dispersion measures over time. The other notion of convergence i.e., beta convergence, applies when a poor state tends to ‘catch up’ the richer ones in terms of average productivity. Sala-i-Martin (1996) pointed out that beta convergence is a necessary but not a sufficient condition for achieving sigma convergence. Modeling approach to beta convergence has come across several stages from the conventional cross sectional regression to dynamic panel models.

In this study we first investigate unconditional or absolute beta convergence which assumes structurally homogeneous cross section units (states, in this study) unlike conditional beta convergence where some state-specific explanatory variables are used in the analysis. For testing unconditional beta convergence we have followed the panel unit root approach. Defining y_{it} to be $\ln(Y_{it})$ where Y_{it} is the foodgrains yield in the i th state at t th time point, the panel unit root tests on the demeaned series($\tilde{y}_{it} = y_{it} - \bar{y}_t$) of y_{it} ,where $\bar{y}_t = \frac{1}{n}\sum_{i=1}^{n} y_{it}$, proposed by Levin *et al*. (2002) , Im*et al*. (2003),and Maddala and Wu (1999) , have been applied (see, Mukhopadhyay and Sarkar (2015) for a brief description of these tests).

The static panel regression approach that is followed in our analysis for testing conditional beta convergence in foodgrains productivity considers the following regression equation:

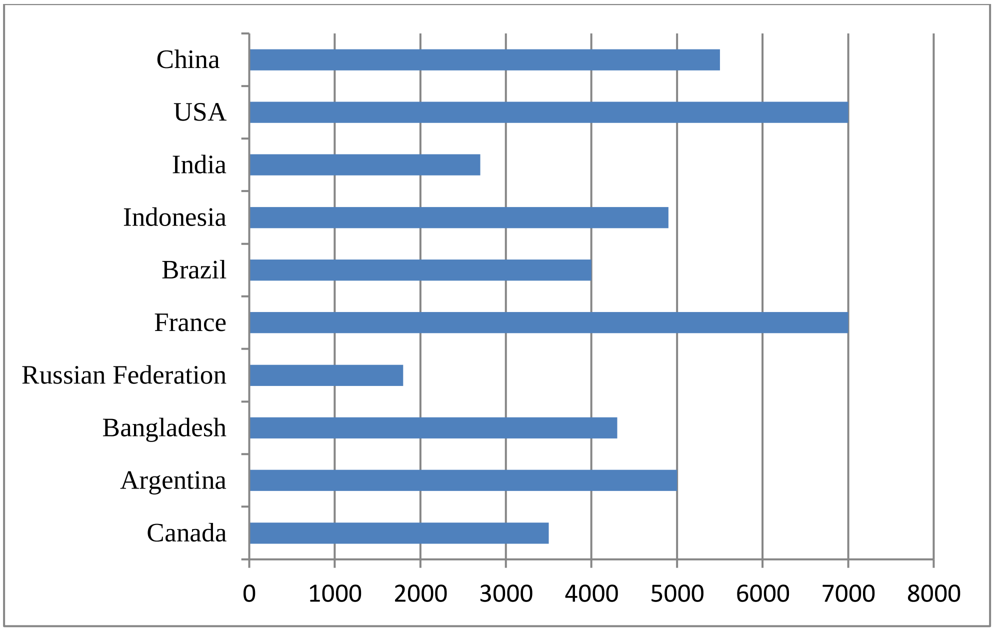
$$\frac{1}{\tau}\ln(\frac{Y_{it}}{Y_{i,t-\tau}}) = \mu_i + \beta \ln Y_{i,t-\tau} + \delta X_{it} + \varepsilon_{it} \quad (1)$$

where foodgrains yield and irrigated land (in percentage)[1] in state *i* at time *t* are represented by Y_{it} and X_{it}, respectively. If β is significant and negative then the resultant conditional convergence holds. The state specific fixed effect is captured by μ_i We have carried out this exercise for two choices of τ *viz.,* $\tau =1$ and $\tau =5$ The Hausman specification test has been applied to decide between fixed effect model and random effect model. Further, the White's heteroscedasticity consistent sampling variances and covariances have been used in the estimation results.

As regards studying the convergence issue from consideration of dynamic panel model, the first differenced generalized method of moments(GMM) method of Arellano and Bond(1991) and the system GMM method of Bond and Blundell (1998) have been applied.

3. Empirical Results

This section discusses the empirical findings on convergence analysis of foodgrains productivity across the major foodgrains producing states of India over the time period 2000-01 to 2012-13 using the methodology stated in the preceding section. By looking at the figures on foodgrains productivity, we first note that productivity of foodgrains in India is rising rapidly although yield of most of the crops are still below the world average (FAO Report , 2009). We have presented cereal productivity of the world's top ten producers in the year 2010 in Figure 1 below. This figure shows that although India is the third largest producer of cereal after China and the USA, it's productivity is 2700 kg per hectare which is second lowest among the top ten producers of cereals in the world. India's average yield is below the world average as also of Asia's average. However, there exists widespread regional disparity in foodgrains productivity among the major foodgrains producing states of India (cf. Table 1). The states with high initial levels of productivity in 2002-03 (for example, Punjab, Haryana, and West Bengal) have relatively lower rates of growth in productivity during the decade 2002-03 to 2011-12. On the other hand, states like Rajasthan, Chhattisgarh,, Madhya Pradesh, Gujarat and Rajasthan are showing high growth in productivity despite having low productivity initially. This is an indication towards convergence in productivity across the states.



Source: FAO 2013 Statistical Yearbook

Figure 1. Productivity of World's Top Ten Cereal Producers (kg/hectare) in 2010

In order to select the state specific variables determining productivity, we have estimated a cross section regression model with the three independent variables viz., irrigated area (in percentage), average land holding (in hectare) and agricultural credit share, for all of which data are available latest for the year 2006-07. The estimation results are presented in Table 2. It is evident from the results that only the explanatory variable, irrigated area, is significant in explaining variations in productivity across the states. This finding is very significant in explaining the role of gross capital formation in agriculture. While this finding is expected, the lack of significance of the other two explanatory variables viz., average land holding and agricultural credit share is somewhat unexpected. The final estimated cross section regression with the significant explanatory variable, irrigated area, denoted as Z_1 ,has been obtained as

$$\ln \hat{Y} = 6.932 + 0.012 Z_1 \quad Adj.R^2 = 0.441$$

(40.712)* (3.864)*

(The values in parentheses indicate *t*-statistic values; *indicates significance at 1 percent level of significance)

Table 1. Foodgrains Productivity and Growth across States of India

States	**Foodgrains Productivity (kg/hectare) in 2002-03**	**Decadal Growth (from 2002-03 to 2011-12 of foodgrains productivity (in percentage)**
Andhra Pradesh	1694	43.5
Assam	1417	28.8
Bihar	1568	39.6
Chhattisgarh	651	84.4
Gujarat	1114	58.0
Haryana	3103	17.5
Jharkhand	1053	56.9
Karnataka	949	43.9
Kerala	2151	5.1
Madhya Pradesh	943	56.3
Maharashtra	846	22.3
Orissa	716	84
Punjab	3828	10.7
Rajasthan	873	52.9
Tamil Nadu	1612	30
Uttar Pradesh	1995	24.4
Uttarakhand	1508	25.1
West Bengal	2374	13.3

We now present the results on sigma convergence diagrammatically in Figures 2 and 3. The line diagram of cross sectional standard deviations of the logarithm of productivity of foodgrains for the major 18 Indian states over the period 2000-01 to 2012-13 is presented in Figure 2. This shows a somewhat downward trend after 2002-03 indicating declining standard deviations which implies sigma convergence. The value of the standard deviation has fallen from 0.529 in 2000-01 to 0.339 in 2012-13. The coefficient of variation , which is another measure of sigma convergence, also shows downward movement as presented in Figure 3. Its value has reduced from 0.072 in 2000-01 to 0.044 in 2012-13.

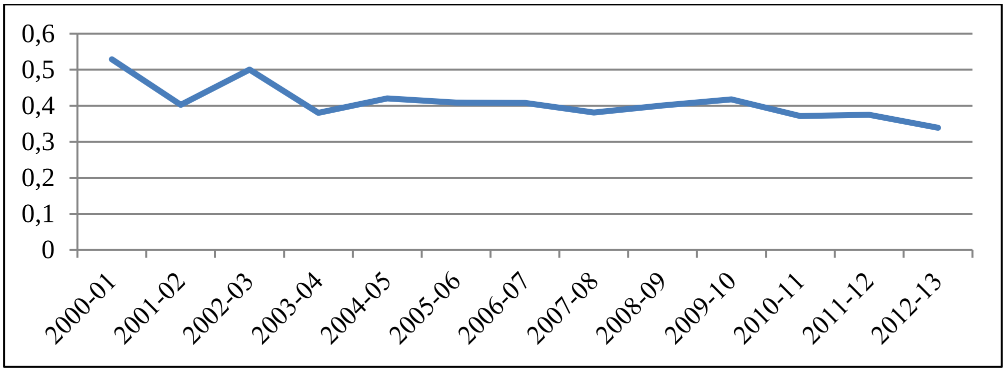


Figure 2. Sigma Convergence based on Standard Deviation of Foodgrains Productivity of States from 2000-01 to 2012-13

As regards the regression results on sigma convergence, the simple regressions of both the measures of sigma convergence on time are reported in Table 3. For both the measures, significant negative trend have been found. These results clearly suggest sigma convergence in foodgrains productivity across the major foodgrains producing 18 states of India during the period 2000-01 to 2012-13.

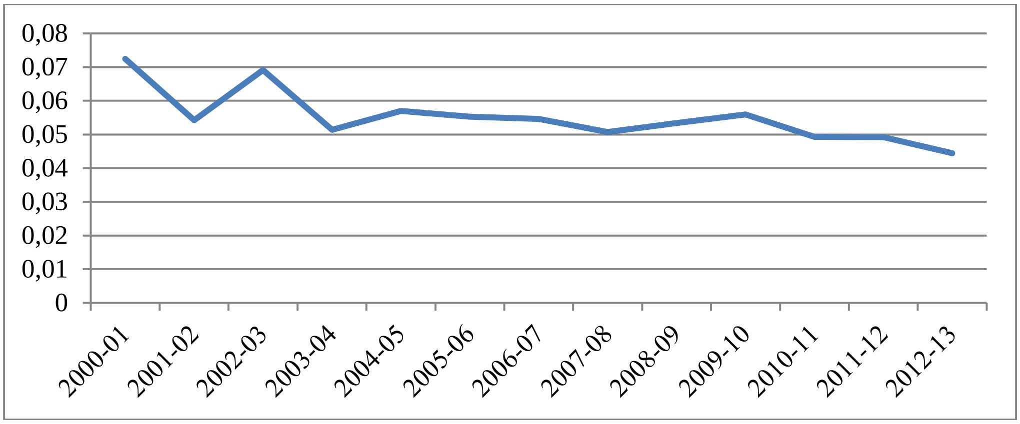


Figure 3. Sigma Convergence based on Coefficient of Variation of Foodgrains Productivity of States from 2000-01 to 2012-13

As already discussed in the previous section, the other important measure of convergence i.e., beta convergence, implies low productivity states tend to grow faster than high productivity states in terms of productivity growth. The panel data approach of beta convergence first uses the panel unit root test on the demeaned series of logarithm of productivity level. The results of this test are presented in Table 4.

Table 2. Cross Section Regression Results

Dependent Variable: ln (foodgrains productivity)				
Independent Variable	**Coefficient**	**Standard Error**	**t-statistic**	**p-value**
Constant	7.010	0.214	32.865	0.000
Irrigated area	0.013	0.005	2.731	0.017
Av. land holding	-0.139	0.119	-1.168	0.264
Agr. credit share	0.017	0.025	0.684	0.506

Table 3. Regression Results on Sigma Convergence based on Standard Deviation and Coefficient of Variation

Dependent Variable: Standard Deviation				
Variable	**Coefficient**	**Standard error**	**t-statistic**	**p-value**
Constant	0.478	0.022	21.686	0.000
time	-0.010	0.003	-3.463	0.005
Adj.R^2= 0.478				
Dependent variable: Coefficient of Variation				
Constant	0.066	0.003	20.664	0.000
time	-0.001	0.0004	-3.721	0.003
Adj.R^2= 0.517				

The null hypothesis in case of panel unit root tests assumes unit root i.e., nonstationarity of the panel. The value of the LLC (due to Levin et al. (2002)) test statistic is -4.435, which is highly significant at 1% level of significance, and hence the null of nonstationarity is rejected in favour of staionarity in the demeaned series. Thus, it is concluded that based on the results of this test, the foodgrains productivity shows convergence across the 18 major foodgrains growing states. The same conclusion is also drawn from the IPS(due to Im et al. (2003)) test , the Fisher's chi-square (ADF version), and Fisher's chi-square(PP version) tests since values of all these test statistics are highly significant. In all these tests we have used Schwartz's Bayesian information criterion (BIC) for lag selection. Thus, all the panel unit root tests infer stationarity in the demeaned series of logarithm of foodgrains productivity. Hence, we conclude that convergence in foodgrains productivity holds across the major foodgrains producing states in India.

Table 4. Panel Unit Root Test Results on Demeaned Series

Panel unit root test	Test statistic value	p- value
Levin-Lin-Chu unit-root test (LLC)	-4.435	0.000
Im-Pesaran-Shin unit-root test (IPS)	-2.744	0.000
Fisher-Chi-square test (ADF)	95.992	0.000
Fisher-Chi-square test (PP)	145.800	0.000

We now report the results of conditional beta convergence by using the static panel regression model in Table 5. Unlike absolute convergence where we do not consider any explanatory variable(s) for capturing cross-sectional heterogeneity, here we have explanatory variables. To be specific, for the purpose of testing for beta convergence , we have used the regression equation in (1) where the logarithm of initial productivity level and irrigated area have been taken as the regressors. Obviously , the beta convergence here is conditional. This analysis is based on data from 2001-02 to 2011-12 since the time series for irrigated area is available only for this period.

Table 5. Results on Conditional Beta Convergence

Dependent Variable: $\ln Y_{it} - \ln Y_{i,t-1}$				
Variable	Coefficient	Standard error	t-statistic	p-value
Constant	6.250	0.652	9.600	0.000
$\ln Y_{i,t-1}$	-1.024	0.098	-10.483	0.000
X_{it}	0.032	0.005	6.186	0.000
Dependent Variable: (1/5)*($\ln Y_{it} - \ln Y_{i,t-5}$ **)**				
Constant	1.157	0.135	8.563	0.000
$\ln Y_{i,t-5}$	-0.183	0.016	-11.674	0.000
X_{it}	0.005	0.001	3.419	0.001

Note: $\ln Y_{i,t}$ is the logarithmic value of foodgrains productivity for the i th state in t th year ; X_{it} denotes irrigated area (in percentage) for the i th state in t th year ; Adj R-squared values are 0.484 and 0.627, respectively.

In Table 5, we first present the panel regression results for $\tau = 1$ In this regression the beta coefficient is found to be highly significant and negative (-10.483), implying thereby an inverse relationship in productivity growth and its initial level. Moreover, the explanatory variable , irrigated area, is highly significant with the estimate being 6.186. Since its sign is positive, it can be concluded that higher percentage of irrigated land makes a positive impact on productivity growth. These findings thus confirm conditional beta convergence.

Table 6. Results on Convergence in Foodgrains Productivity for Dynamic Panel

Arellano-Bond dynamic panel data estimation				
Variable	**Coefficient**	**Std. Error**	**t-Statistic**	**p-value**
$\ln Y_{i,t-1}$	-0.095	0.026	-3.60	0.000
$X_{i,t}$	0.039	0.002	22.30	0.000
Constant	6.487	0.164	39.63	0.000
System dynamic panel data estimation				
Variable	Coefficient	Std. Error	t-Statistic	p-value
$\ln Y_{i,t-1}$	0.207	0.061	3.40	0.000
$X_{i,t}$	0.024	0.001	21.71	0.000
Constant	4.87	0.427	11.41	0.000

Note: Two step estimation are followed

We have also carried out the Hausman specification test for deciding between fixed effect model and random effect model in the static panel data analysis. We find from Table 5 that the chi-square test statistic value is 101.94 which is highly significant at 1% level of significance. This implies rejection of random effect model in favour of fixed effect model. Accordingly, the fixed effect model has been used. In order to take care of the possible cross sectional heterogeneity, we have used White's heteroscedasticity consistent variances and covariances in estimation.

The static panel regression has also been obtained for τ=5 and the results are also presented in Table 5. These results also show negative significant β coefficient with the test statistic value being -11.674. The explanatory variable is also highly significant with positive sign, the value being 3.419 . The adjusted R^2 value for this regression is 0.627 which is higher than in the previous case i.e., 0.484. These static panel regression results discussed above strongly suggest conditional convergence in the foodgrains productivity across Indian states.

Apart from static panel, we have also conducted the dynamic panel exercise to strengthen our findings since the former cannot capture the dynamic relationship in the panel data. The dynamic panel results are presented in Table 6. It is evident from the first differenced GMM that the estimate of the coefficienct corresponding to the lagged dependent variable is -0.095 which is less than one and statistically significant. This implies convergence in foodgrains productivity in first differenced GMM panel model. The same conclusion also holds for the system GMM panel model. Thus, conditional convergence is established for foodgrains productivity for dynamic panel model.

Table 7. Sigma Convergence Results on average Cost of Production in Paddy and Wheat

Year	Paddy		Wheat	
	Standard deviation	Coefficient of variation	Standard deviation	Coefficient of variation
2005-06	0.133	0.021	0.127	0.020
2006-07	0.134	0.021	0.096	0.015
2007-08	0.210	0.033	0.079	0.012
2008-09	0.186	0.028	0.074	0.011

Finally, the testing of convergence hypothesis for productivity looks at the convergence problem in respect of outcome rather than means. It is , in fact, the latter that can explain the source(s) of convergence or divergence in outcome. In this context, we have examined whether there has been convergence in average cost of production in some selected principal crops viz., paddy and wheat, in some selected states[2] during the period 2005-06 to 2008-09 following the sigma convergence measure, namely, convergence in terms of standard deviation as well as coefficient of variation. These results are presented in Table 7. It is evident from the table that the values of (cross sectional) standard deviation and coefficient of variation of average cost of production of paddy do not show any declining trend. In terms of the former, the value has, in fact, increased from 0.133 in 2005-06 to 0.186 in 2008-09. Similar is the case with coefficient of variation. Thus it is concluded that there is no convergence in terms of sigma convergence of average cost of production of paddy in India. But for wheat, there is a clear declining trend in both standard deviation and coefficient of variation of average cost of production. The value in case of standard deviation has declined steadily from 0.127 in 2005-06 to 0.074 in 2008-09 while that for standard deviation the decrease is from .020 in 2005-06 to 0.011 in 2008-09. It is thus clearly established that there is sigma convergence in the average cost of production of wheat in the major wheat producing states. It can thus be inferred that the convergence in foodgrains productivity among major foodgrains-growing states of India can be explained in terms of convergence in average cost of production ofwheat.

4.Conclusions

This study investigates the convergence hypothesis in the productivity of foodgrains in terms of output per unit of cropped area during the period 2000-01 to 2012-13 across the major 18 foodgrains producing states of India using the two standard measures of convergence viz., sigma convergence and beta convergence. This has been done by applying the modern econometric tools available for panel data analysis, namely, panel unit root tests on demeaned series, static panel regression and dynamic panel regression , apart from conventional measures based on standard deviation and coefficient of variation.

As convergence of productivity depends on the state specific factors, a cross section regression for the year 2005-06 has been done to find the important explanatory variables in explaining variations in foodgrains productivity across states , and irrigated cropped area is found to be the only significant explanatory variable. The sigma convergence measures show negative trend over time implying convergence in foodgrains productivity. The panel unit root test on the demeaned productivity (logarithmic) series is found to be stationary by all the standard tests. This evidence found is thus in favour of (absolute) beta convergence. The static panel regression shows an inverse relationship between growth rate and lagged dependent variable implying a conditional beta convergence in the series. The dynamic panel model also shows evidence in favour of (conditional) beta convergence. In both the static and dynamic panel models irrigated area is found to be statistically significant with positive sign indicating the significant role of infrastructure in agriculture.

Apart from finding out convergence in productivity which is an outcome, we attempted, in a limited way, to find whether this convergence in outcome is due to convergence in means i.e., inputs or cost of production. We found sigma convergence in average cost of production of wheat, but not of paddy. This evidence clearly establishes the role of technological spillover across the states, and its effect in achieving convergence in foodgrains productivity. Finally, this empirical evidence on convergence in foodgrains productivity in major foodgrains-growing states of India also demonstrates that higher growth in relatively low productivity states will be able to enhance agricultural income in these regions. Consequently, rural poverty reduction should be quite fast since agricultural growth is the key to connecting the poor to growth.

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[1]Although there are other state-specific explanatory variables for agricultural productivity, but due to lack of availability of any time series data for the 17 states, these could not be included in this static panel regression. There are only two explanatory variables viz., average land holding (in hectare) and agricultural credit share, for which data are available for the 18 states but that too for one or two years only. However, as reported in the next section, in cross-section regression , based on data for 2006-07 only, these two variables have been found to be statistically insignificant**.**

[2] The states are selected on the basis of availability of data from www.indiastat.com. The six states for consideration of production paddy are Andhra Pradesh, Bihar, Haryana, Madhya Pradesh, Punjab and Uttar Pradesh whereas the five states for wheat are Haryana, Madhya Pradesh, Punjab, Rajasthan and Uttar Pradesh.