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Agricultural Growth and Economic Convergence in Indian Agriculture

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ABSTRACT

The benefits of agricultural growth have been concentrated in India's richer states, leaving the poorer states lagging further behind. The convergence process of agricultural economic growth in the context of globalisation and economic liberalisation would reveal the implications for support for or withdrawal from economic reform and for further opening of the Indian economy. Evidence of absolute β-convergence in per hectare net state domestic product (NSDP) agricultural levels across Indian states reveals the tendency of states to converge to identical steady states level. Bernard Jones approach confirms that convergence is conditional. Fertiliser, public finance, small-landholdings, cropping intensity, agricultural research and education, physical infrastructure, agricultural mechanisation and diversification were the discerned factors for causing conditional convergence. The study concludes that the benefits of economic reforms started by Government of India have shown impact on the convergence process of per hectare NSDP agriculture among Indian states.

Keywords: Economic convergence, Agricultural growth, India

JEL: Q100, C330, F180

I

INTRODUCTION

Nature has put limits on the potential of agricultural productivity in a region endowed with natural resources, level of infrastructure besides prevailing policy environment. The driver of narrowing down the gap between potential productivity and realised productivity is agricultural growth. The performance of Indian agriculture differs markedly across policy regimes especially in the era of state planning up to 1991, and market – reform period since 1991 (Bhattacharya and Sakthivel, 2004). The deepening and widening of Borlaug technology in pre-reform period led to remarkable growth of agricultural output in the irrigated belt of India. Significant growth changes in the cropping pattern with a visible shift in crop diversification away from coarse cereals towards rice and wheat in the north-western and eastern states. But the post reform period is characterised by serious retrogression both in the matter of levels and growth rates of yield and output in most states and regions (Bhalla and Singh, 2009). Despite this, India's recent strong growth performance, there is growing concern that the benefits of agricultural growth have been concentrated in India's richer states, leaving the poorer states lagging further

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behind. As India's poorest states are also most populous, the concern is that unless these states begin to share in the benefits of growth, an increasing proportion of the population will be left in poverty and that rising inequality will lead to social, political, and economic difficulties. The differential agricultural performance across states has begun to raise important policy questions within India.

Understanding the causes and nature of differences in the levels and growth of income across the regions is very important because even small differences in the growth rates, if accumulated over a long period of time, may have substantial impact on the standards of living of people (Barro and Sala-i-Martin, 1995). Moreover, as many perceive that globalisation and economic liberalisation have contributed to this state of affairs, economic divergence could erode the support for economic reform and for further opening of the Indian economy. Indian agriculture exhibits considerable heterogeneity in physical geography, climate, culture, infrastructure, production structure and socio-cultural development; and the inter-state variation in agricultural income growth could be due to significant differences in such structural characteristics across states (Birthal *et al*., 2009). Some states have achieved rapid agricultural output growth in recent years, while others have languished. For instance, the states in the Central Region have diversified in favour of cotton and oilseeds as also towards the remaining crops (fruits, vegetables and spices), despite weather-induced uncertainties. These risks are further exacerbated because of increased vulnerability to world commodity price volatility following trade liberalisation. These risks pose a serious problem for the livelihoods of cotton and oilseeds farmers driving some of them to utter desperation leading to suicides (Bhalla and Singh, 2009).

There is a rich literature available in recent years on the investigation of the trend in regional disparities in economic development in India and causes thereof (Cashin and Sahay, 1996; Bajpai and Sachs, 1996; Nagaraj *et al.*, 1998; Rao *et al*., 1999; Aiyer, 2001, Sachs *et al*., 2002; Trivedi, 2003; Purfield, 2006; Nayar, 2008; Birthal *et al*., 2009), and find a steady rise in regional disparities due to cross-state differences in infrastructure, human capital and technology. Moreover, even if there has been evidence of either absolute or conditional convergence, the speed of convergence differs per se from low, 1.5 per cent (Cashin and Sahay, 1996) to high, 20 per cent (Aiyer, 2001) and 34 per cent (Nagaraj *et al.,* 1998). The Indian studies on growth and convergence have used different samples of states over different time periods and arrived at times at conflicting conclusions.

The most popular formal model underlying the idea that initially the poorer regions might grow faster is the neoclassical growth model of Solow (1956). The key assumption that generates the convergence result in neoclassical models is diminishing returns to reproducible capital. While some of these studies reveal that the growth pattern of per capita income has followed a divergent tendency in absolute terms (Margit and Mitra, 1996; Rao *et al*., 1999; Dasgupta *et al*., 2000, Birthal *et al*., 2009).

In spite of considerable research undertaken on the subject, hardly any study has been conducted by any researcher on agricultural growth and convergence in per hectare total output value of agriculture in India. In light of this backdrop, this paper seeks to shed light on the subject by asking whether per hectare total value of agricultural output levels across Indian states have been converging or diverging, if converging then at what pace; and lastly identifying the factors conditioning convergence. Based on the findings, suitable policy options would be suggested for equitable agricultural development across Indian states. Sections II and III presents the facts about the levels and agricultural growth of total value of output per hectare across Indian states. Section IV assesses empirically the question of convergence and the impact of state policy on agricultural growth is presented in Section V. The final section presents the conclusions.

II

METHODOLOGY AND DATA

Analytical Approach

Convergence is the tendency of poorer economies to grow faster and catch up with richer economies (Barro, 1991 and Barro and Sala-i-Martin, 1995) and is of two types: σ-convergence and β-convergence. σ–convergence is measured as the standard deviation in logarithm of per hectare total output value of agriculture including livestock across regions and denotes the evolution of cross-sectional dispersion of per hectare total output value of agriculture – its shape and the movement of the distribution of value of total output over time. It occurs if the dispersion of per hectare total output value of agriculture across regions declines over time. If different initial conditions do not matter, β-convergence may eventually lead to σ–convergence. This is known as unconditional or absolute β-convergence. Manwik *et al*. (1992) deciphered a natural way to study convergence because an augmented Solow-model expresses growth as an explicit function of the determinants of the ultimate steady state and the initial level of income. β-convergence shows relationship between growth rate of per hectare total output value of agriculture and initial level of per hectare total output value of agriculture of regions, and is said to occur if the relationship between the two is significantly negative. The idea is that a poor economy tends to grow faster than a rich one in the transitional period and possibly tends to catch up with the rich one in terms of the level of per hectare total output value of agriculture. The key assumption in neoclassical model is diminishing returns to reproducible capital. The relatively less well off economy will have lower stocks of physical capital, hence higher marginal rates of returns on capital. Therefore, for any given rate of investment, it will have faster growth in the transition phase. The relationship between growth rate in per hectare total output value of agriculture of region 'i' and its initial level of per hectare total output value of agriculture can be estimated as:

$$\Delta y_{it} = \beta\, y_{it} + y x_{it} + \varepsilon_{it} \qquad \text{….(1)}$$

Where y_{it} is per hectare income of region 'i' at the beginning of the period, Δy_{it} is the growth rate per hectare income over the period, x_{it} is the set of variables influencing growth of region i, and ε_{it} is the random disturbance, for convergence the coefficient of y_{it} must be significantly less than zero.

Equation (1) also known as barrow regression is the representation of the notion of conditional β-convergence. Conditional β-convergence however is relevant when the regional economies are not structurally similar. In other words, absolute β-convergence assumes homogeneity of structural characteristics (technology, preferences, culture, etc.) across countries/regions. Absolute β-convergence is a stronger version of β-convergence and occurs once the variation in structural characteristics is controlled for. Thus for absolute β-convergence $\tilde{x}_{it}$'s in Equation (1) should be jointly insignificant. Hence, β-convergence is consistent with σ-divergence. Equation (1) can be estimated using both cross-section and panel data specifications. We use panel data specification because of its several advantages over cross-section specification (Islam, 1995). Panel data specification provides for large number of observations, allowing for more degrees of freedom, reduced collinearity among independent variables, and increased probability of getting more reliable parameter estimates (Wooldridge, 2002). Further, with panel data it is possible to control region-specific, time-invariant characteristics using fixed effects or random effects models, which is not possible with cross-section specification.

Another approach a bit different is developed by Bernard and Jones (1996), which checks for convergence and its nature (conditional or unconditional) without controlling for structural variables. This approach tests the convergence against a benchmark region. Let the benchmark region be r, then the difference in per hectare income of region i from region r can be expressed as:

$$LnD_i(t) = LnA_r(t) - LnA_i(t) \qquad \text{….(2)}$$

Where i=1, 2,……….N. $A_i(t)$ is per hectare total output value of agriculture of region 'i' in year t, and $A_r(t)$ is per hectare total output value of agriculture of the reference region r, and both are in logarithms. Then $D_i(t)$ is the per hectare total output value of agriculture of region 'i' relative to the region r. If there is a convergence between regions i and r, then $D_i(t)$ is stationary. The estimated equation is then:

$$LnD_{it} = (\delta_r - \delta_i) + (1 - \lambda)\, LnD_{it-1} + \varepsilon_{it} \qquad \text{….(3)}$$

If there is no convergence, then λ=0 and ($\delta_r \neq \delta_i$) If λ is significantly >0 and ($\delta_i = \delta_r$), then the regions will converge to the same level of per hectare total output value of agriculture. The drift term will be small but non-zero. If ($\delta_r = \delta_i$) then convergence is absolute. In other words, for absolute convergence drift term should be insignificantly different from zero.

Data

We examine the process of convergence and its underlying causes using data for 15 major Indian states for the period 1980-81 – 1994-95, 1995-96 – 2009-10 and 1980-81 – 2009-10- a period before and after the formation of World Trade Organization (WTO). The sample states are: Andhra Pradesh, Bihar, Gujarat, Haryana, Himachal Pradesh, Karnataka, Kerala, Madhya Pradesh, Maharashtra, Orissa, Punjab, Rajasthan, Tamil Nadu, Uttar Pradesh and West Bengal.[1] Together, these account for 94 per cent of the country's population and 90 per cent of the gross domestic product (GDP of agriculture).

For the purpose, the data were compiled from various published sources. In this paper, we define per hectare total value of output as the GDP of agriculture per hectare, and information on GDP of agriculture was collected from various issues of the *National Accounts Statistics* published by Central Statistical Organisation of the Ministry of Statistics and Programme Implementation, Government of India. Data on demographic variables were compiled from Census of India- conducted decennially by the Government of India. Data related to gross cropped area, inputs infrastructure and agricultural technology was collected from the Statistical Abstracts published by different states, and also from reports of Centre for Monitoring Indian Economy (CMIE). As we use panel data specification, the entire period from 1980-81 to 2009-10 is divided into five sub-periods - each comprising 5 years. Thus, the total number of observations for 15 states becomes 75, as against 15 in cross-section specification. Panel data approach is superior to cross sectional data since cross sectional approach implicitly assumes the same production function for different regions and may be inappropriate if heterogeneity across regions is significant.

III

GROWTH PERFORMANCE OF STATES, AND CONVERGENCE

Regional Scenario of Per Hectare Productivity and Agricultural Growth

Table 1 also compares the growth rates of per hectare NSDP (Net State Domestic Product) of agriculture of states for the period 1980-81-1994-95 and 1995-96-2009-10. We have taken 1995-96 as the cut–off point because India initiated economic reforms in agriculture after the formation of WTO. India's per hectare NSDP of agriculture grew at an annual rate of 2.74 per cent during 1980-81-1994-95 and 2.10

per cent during 1995-96 – 2009-10. Furthermore, the gap between poor and rich states has decreased slightly over the last three decades. For instance, the ratio of per hectare NSDP of agriculture of the poorest state Rajasthan to one of the richest states Kerala has decreased to 3.64 in 2007-09 from 4.05 in 1980-82. However, the robust growth observed at the national level is not universal, but there are considerable inter-state variations in the agricultural aspects of various states. The states are arranged in an ascending order of productivity during TE 1980-82. Per hectare NSDP during TE 1980-82 was the highest in Kerala closely followed by Himachal Pradesh. Punjab ranked third and West Bengal got fourth rank. The lowest level of agricultural productivity was recorded in Rajasthan, followed by Madhya Pradesh. Maharashtra ranked third from bottom with per hectare productivity of Rs. 6,722 which was just half (50 per cent) of all-India average. Ranking of various states based on the productivity witnessed profound changes during reform period because of variations in the growth rate of NSDP agriculture. It is interesting to note that the two states, namely, Rajasthan and Madhya Pradesh, which were among the bottom three states in terms of productivity in pre-reform period, gained momentum in the growth rate of NSDP agriculture during post-reform period. These states recorded 3.49 and 2.68 per cent annual growth rate in the total output value in agriculture in pre-reform period. All the states except Rajasthan, which had productivity lower than the national average, witnessed a higher growth in productivity in the post-reform period as compared to pre-reform period. This shows that the growth experience during post-reform period favoured the agriculturally underdeveloped states more than the other states. But Rajasthan, despite a high growth rate in pre-reform period, remained at the bottom in agricultural productivity.

TABLE 1. LEVEL AND GROWTH IN PER HECTARE NSDP OF AGRICULTURE INCLUDING LIVESTOCK-(2004-05 BASE)

	Average per hectare NSDP (Rs./ha)			Annual compound growth rate in per ha NSDP (per cent)	
States	TE-1980/82	TE-1994/96	TE-2007/10	1980-81/ 1994-95	1995-96/ 2009-10
(1)	(2)	(3)	(4)	(5)	(6)
Rajasthan	6273 (15)	10440 (14)	10834 (14)	3.49 (4)	1.46 (13)
Madhya Pradesh	6401 (14)	9442 (15)	9614 (15)	2.68 (9)	3.63 (3)
Maharashtra	6722 (13)	13278 (12)	11705 (13)	3.98 (3)	4.12 (2)
Bihar	12120 (12)	11617 (13)	13645 (12)	0.87 (14)	4.86 (1)
Karnataka	13174 (11)	19528 (10)	19902 (10)	2.87 (8)	0.76 (14)
Orissa	13267 (10)	26075 (7)	14129 (11)	-0.17 (15)	1.75 (9)
Gujarat	14175 (9)	14677 (11)	20336 (9)	1.23 (13)	3.55 (4)
Uttar Pradesh	15448 (8)	19818 (9)	21991 (8)	2.47 (11)	1.90 (7)
Tamil Nadu	15840 (7)	21773 (8)	29490 (5)	4.53 (1)	2.55 (6)
Haryana	17276 (6)	26974 (6)	26363 (6)	3.45 (6)	1.74 (10)
Andhra Pradesh	18838 (5)	30714 (3)	25770 (7)	2.46 (10)	-1.00 (15)
West Bengal	18958 (4)	29511 (5)	36146 (2)	4.17 (2)	1.64 (11)
Punjab	19423 (3)	34819 (2)	30647 (4)	3.57 (5)	1.84 (8)
Himachal Pradesh	22988 (2)	30489 (4)	30895 (3)	2.33 (12)	3.00 (5)
Kerala	25399 (1)	39353 (1)	39466 (1)	3.24 (7)	1.48 (12)
All India (15 states)	12561	18641	18782	2.74	2.1

Figures in parentheses are ranks of states.

The agriculturally developed states, in terms of productivity, namely, Kerala and Himachal Pradesh, also witnessed a reasonably high growth in output during pre-reform period. However, the growth rate in Kerala was slightly more and growth rate in Himachal Pradesh slightly less than the national average. Tamil Nadu witnessed a relatively high growth (4.53 per cent) in this period. Agricultural output in West Bengal also increased at a high rate (4.17 per cent) during 1980-81 to 1994-95. This period turned out to be very adverse for Orissa, Gujarat and Bihar, all of which witnessed very high year-to-year fluctuations in the agricultural output with a meager growth rate. But ranking of five bottom states based on productivity during TE 1994-96 compared to productivity during TE 1980-82 could reveal slight change in positions except significant gain in the positions of Orissa and Andhra Pradesh.

The growth experience in the post-reform period is very different than that of the pre-reform period. It turned to be adverse for most of the rich states. Growth of per hectare NSDP of agriculture of states, viz., Punjab, Haryana, Kerala and West Bengal except Himachal Pradesh, not only decelerated significantly in the post-reform period but also trailed further below the national average. The most affected state was West Bengal, where the NSDP in agriculture approaches 1.64 per cent annually. This relegated West Bengal from second top position to bottom 11th position in productivity per unit of land. In contrast, the poor category states except Karnataka experienced rapid growth of per hectare NSDP of agriculture in post-reform period. Gujarat also experienced robust growth of 3.55 per cent a year- around triple the growth realised in pre-reform period. After witnessing a growth rate of 2.46 per cent in pre-reform period, Andhra Pradesh's NSDP in agriculture slumped to -0.10 per cent annually in post-reform period. Similar was the experience of Karnataka. This means that less developed states have harvested the gains of new economic reforms in terms of higher growth in the post-WTO period in comparison to pre-WTO period. The growth of per hectare NSDP agricultural experience shows that in both the periods, the growth rate of per hectare NSDP in agriculture in most of low productivity states was much lower than the national average but in the post-reform period, the growth rate in most of the low productivity states was higher than that of pre-reform period but also turned out to be lower than the national average.

IV

CONVERGENCE IN PER HECTARE NSDP AGRICULTURE

The general pattern emerging from data presented in Table 1 is that the lower rank states have surged ahead in the post-WTO period and showed tendency of acceleration, rich states faced a deceleration in the post-WTO period and the middle rank states experienced mixed growth in their per hectare NSDP agriculture. This experience can be analysed in another way. Has this pattern of per hectare NSDP agriculture growth led to convergence or divergence among Indian states? First, we investigate this through the lens of σ–convergence. Figure 1 plots standard deviation in logarithm of per hectare NSDP agriculture of states for the period 1980/81-1994/95, 1995/96-2009/10 and 1980/81-2009/10 - a period of pre- and post-reform, and whole period. The standard deviation increased from 0.42 in 1980/81 to 0.45 in pre-reform period, and grew 0.68 per cent a year indicating a clear tendency of divergence in per hectare NSDP agriculture across states. In contrast, the standard deviation decreased from 0.45 to 0.42, and grew -0.48 per cent a year indicating a clear tendency of convergence in per hectare NSDP agriculture across states. In the whole period, standard deviation increased from 0.41 to 0.42, and grew 0.09 per cent a year indicating a clear tendency of divergence in per hectare NSDP agriculture across states.

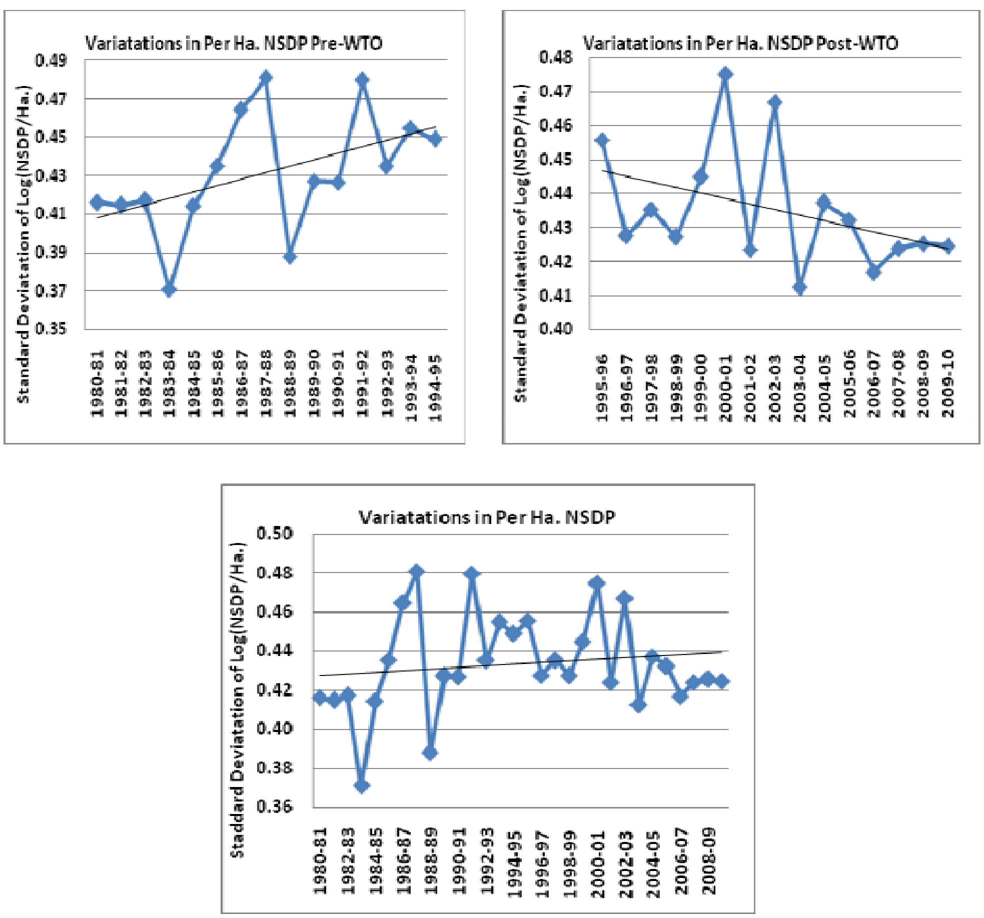

Figure 1. Dispersion of Per Ha NSDP Agriculture including Livestock Across Indian States.

Table 2 shows correlation between the initial value of log per hectare NSDP for the pre-WTO, Post-WTO and overall periods. The correlation coefficient between growth rate and initial level of per hectare NSDP agriculture in pre-WTO period was very small but it shows spectacular increase (-0.46) in the post-WTO period. Moreover, in overall period, it was -0.26. It can be inferred that in pre-WTO period, the convergence in agriculture was very slow but in post-reform period, the convergence in terms of per hectare NSDP agriculture across Indian states was strong. The tendency of divergence was stronger in pre-reform period as compared to the whole period but post-reform period discerned convergence. This finding supports the Kuznets hypothesis that with economic development the first gap between developed and developing states increases and later on decreases because the developing states accelerate their growth.

TABLE 2: RELATIONSHIP BETWEEN GROWTH RATE OF PER HECTARE NSDP AND INITIAL LEVEL OF PER HECTARE NSDP AGRICULTURE

Period (1)	Correlation (2)
Pre-WTO: 1980-81 to 1994-95	-0.02
Post-WTO: 1995-96 to 2009-10	-0.46
Overall: 1980-81 to 2009-10	-0.26

β – Convergence: Figure 2 analyses the existence of β – convergence of per hectare NSDP agriculture across states for pre and post-reform periods, and a whole period. Growth of per hectare NSDP agriculture of agriculturally advanced states has decelerated in the post-reform period but growth of per hectare NSDP agriculturally under-developed states has accelerated in the same period indicating a clear tendency of convergence in per hectare NSDP agriculture. This is evident from the relationship between growth and initial level of per hectare NSDP agriculture which is positive in pre-reform period but is negative in post-reform period. On the whole, the relationship between growth and initial level of per hectare NSDP agriculture is negative. This confirms that growth in per hectare NSDP agriculture of most agriculturally advanced states decelerated considerably and the agriculturally poor states also deciphered substantial improvement in their growth after the initiation of economic reforms process. We can infer the evidence of absolute β – convergence in per hectare NSDP of agriculture levels across Indian states, indicating the tendency of states to converge to identical steady state level.

We further investigate the existence or non-existence of convergence and its nature (absolute or conditional) using Bernard-Jones' approach (1996). We regress deviation in logarithm of per hectare NSDP agriculture of state i in period t from the logarithm of per hectare NSDP of benchmark state r (D_{it}) on the lagged deviation (D_{it-1}). Here, we consider Punjab as the benchmark state because of its continued top rank in income hierarchy for most of the times during last 30 years, using generalised least squares, we estimate fixed and random effects models, and based on Hausman test we chose the fixed effects model.

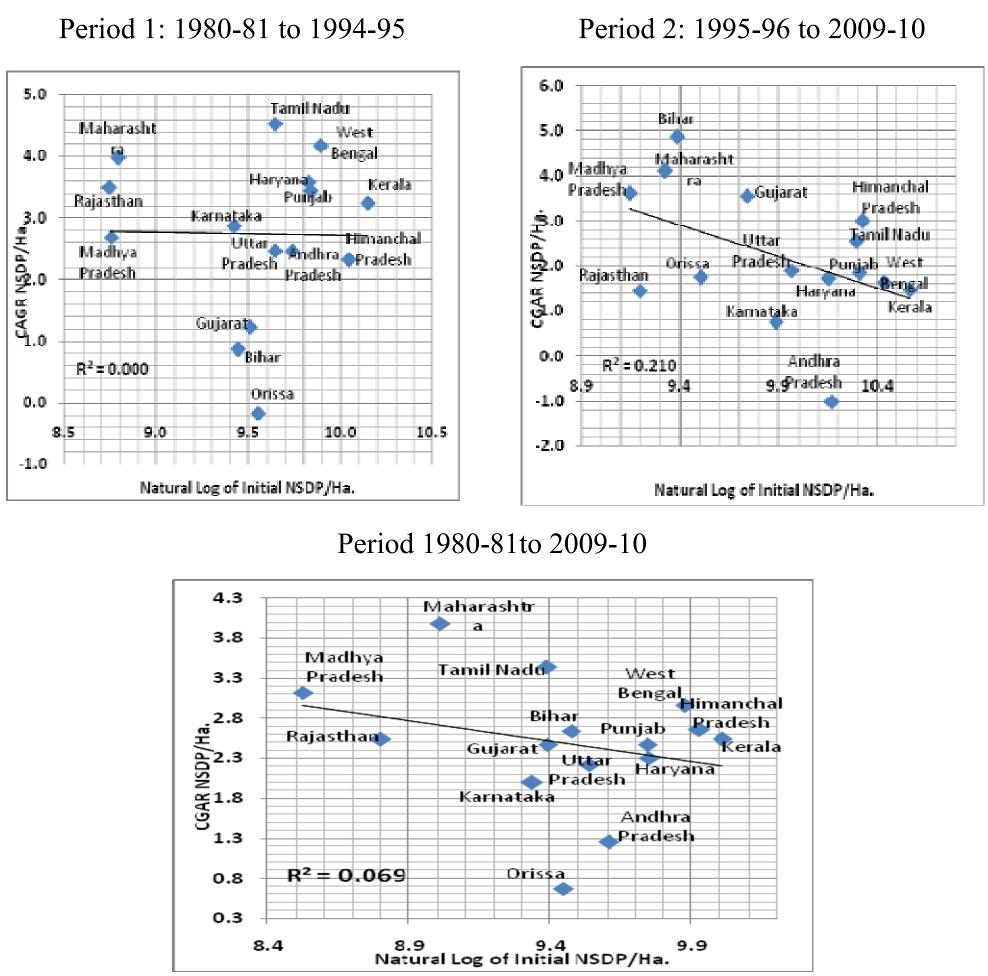

Figure 2. Relationship between Growth Rates in Per Ha NSDP Agriculture including Livestock of States and their Initial Levels of Per Ha NSDP.

The Estimated Fixed Effect equations are:-

(Pre-WTO period: 1980/81-1994/95)
$LnD_{it} = -0.31 + 0.29\ LnDit_{-1}$
(t = -10.10***) (t = 4.11***)
$R^2 = 0.89$, F-statistic = 16.89

(Post-WTO period: 1995/96-2009/10)
$LnD_{it} = -0.23 + 0.41\ LnDit_{-1}$
(t = -9.65***) (t = 6.98***)
$R^2 = 0.93$, F-statistic = 48.78

(Whole period: 1980/81-2009/10)
$LnD_{it} = -0.22 + 0.46\ LnDit_{-1}$
(t = -12.49***) (t = 10.97***)
$R^2 = 0.91$, F-statistic = 120.28
*** Significant at less than one per cent level.

Coefficients of the lagged deviation in per hectare NSDP agriculture in pre- and post-WTO periods, D_{it-1} is an estimate of (1- λ) in equation (3), and are significant at less than 1 per cent level. Values of (1- λ) are 0.29, .41 and .46 in pre-reform, post-reform and whole periods respectively, meaning that $\lambda > 0$. This suggests that there is a convergence in income level across Indian states during the study period, but convergence is not absolute. For absolute convergence, drift $(\delta_r - \delta_i)$ or constant term should be insignificant differently from zero, which is not in the estimated equations. It takes values of 0.31, 0.23 and 0.22 in pre, post and whole periods respectively and is significant at less than 1 per cent level. This implies that convergence is conditional. In other words, for convergence to occur there is a need for measures than enable agriculturally backward states to catch up with agriculturally advanced states.

V

CONDITIONING FACTORS IN AGRICULTURAL CONVERGENCE PROCESS

Lack of convergence in per hectare NSDP agriculture levels can be explained by the differences in physical infrastructure, soil, climate, human capital, technology, institutions, intensity of research and education, cropping intensity, landholdings, mechanisation and diversification across states. Availability of good quality public infrastructure is considered crucial to improving access to markets, to reducing transportation and transaction costs, to improving general quality of life and to stimulate private investment. A high level of human capital allows tangible inputs to be used effectively. To capture effects of infrastructure on income growth we used road length per sq. km. of geographical area (ROAD) as explained by variables in convergence regressions.

Differences in agricultural production structure can also explain the differences in both per hectare NSDP agriculture levels and growth rates across states. Irrigation and rainfall intensity pattern decides the level of agricultural output per unit land. The role of bio-chemical technology in enhancing agricultural output growth as well as economic growth is well recognised in India. In past, this has happened in many developing countries where biochemical technologies based on improved seeds, fertilisers and pesticides could accelerate agricultural growth and thereby labour productivity (Gardner, 2005; Self and Grabowski, 2007). For technological progress, fertiliser consumption was measured as the amount of nitrogen, phosphorous, potassium (NPK) used during a year. We use fertiliser consumption per ha of net sown area (FERT) to assess the role of agricultural technology in output growth.

To purchase all sorts of costly inputs at appropriate time is the need of an hour in agricultural operations especially in Indian agriculture which is dominated by small and marginal farmers. Largely, these farmers are cash starved. To capture the institutional credit flow to agriculture, we use institutional credit as the sum of short term and long term direct agricultural loans advanced during the year by all institutional sources. We use institutional credit per hectare of net sown area (INSTI_CREDIT) to ascertain the role of public finance in the convergence process.

Diversification of agriculture in favour of more competitive and high value enterprises is reckoned as an important strategy of agricultural development (Joshi *et al*. 2004). The relative level of diversification of agricultural across regions within a country will vary, depending on the agro-climatic conditions, resource endowments and infrastructure. To capture the role of diversification, we use percentage share of high value crops in the total agricultural value (DIVERSIFICATION) to ascertain the role of crop diversification in convergence process.

Size of landholding has an inverse relationship between farm size and land productivity (Bhalla, 1979). Lower size of holdings in India have been making more intensive use of land and adopting new technology on a much larger scale compared to the farmers in the larger size categories (Chand *et al.,* 2011). Between 1970-71 and 2005-06, the total number of operational holdings in India increased from 70.10 million to 128.89 million and operational holdings area declined from 162.18 million ha to 156.62 million ha. To capture the role of smallholders, we use percentage share of smallholders in the total number of landholdings (SMALLHOLDERS) to ascertain the role of smallholders in convergence process.

The timeliness of operations has assumed greater significance in obtaining optimal yields from different crops, which has been possible by way of mechanisation. As production increases with mechanisation of the farm operations, it creates a good scope for commercialisation of agriculture. Since the early 1970s, the composition of the relative share of different sources of power for farming operations has undergone significant change. Singh (2009) showed that the share of agricultural workers and draught animals has come down from 63.5 per cent in 1971-72 to 13.7 percent in 2009-10 whereas that of tractors and other power operated machinery has gone up from 36.51 per cent to 86.33 per cent during the same period. To capture the role of mechanisation, we use tractor density per '000 ha of gross cropped area (TRACTORS) to ascertain the role of agricultural mechanisation in the convergence process.

The area under crops can grow through increase in the intensity of cultivation by enhancing irrigation and through introduction of short duration crops. Most of the increase in gross cropped area at the all India and states levels was because of increase in cropping intensity. To capture the role of cropping intensity, we use per cent cropping intensity (CROP_INTENSITY) to ascertain its role in convergence process.

In Figure 1 we noticed a clear evidence of falling regional disparities in India after (WTO) in 1995, and more so in the initial years of reforms. To see whether economic reforms have significantly contributed to fall in disparities we include a dummy variable for reforms (REFORMS) in the convergence regression and takes a value of 1 for the years after 1994/95, zero otherwise.

Using econometric specification in Equation (1) we regressed panel growth rates of per hectare NSDP agriculture of states on initial levels of states' per ha NSDP agriculture and other variables described above using generalized least square method. Based on Hausman test we chose fixed effects model over random effects model. The results are presented in two equations having seven specifications each are given Table 3. All the important determinants in convergence regression model were tested with and without reform dummy variable.

In specification I of Equations (i) and (ii) in Table 3 provide estimates of unconditional β – convergence. Coefficient of initial per ha NSDP agriculture in specification I and II is negative and significant at less than 5 per cent level, indicating the existence of unconditional β – convergence. In specification I, of equation (ii) in Table 3, we include dummy variable for REFORMS together with per ha NSDP agriculture. Coefficient of REFORMS is positive and significant. Besides, the reform coefficient has enhanced the values of coefficient of initial per ha NSDP agriculture. Thus, we can definitely infer that economic reforms have been able to cause convergence among Indian states. In specification II of equation (i) and (ii) in Table 3 provide estimates of conditional convergence and also identify the major factors leading to convergence. First, we look at the role of agricultural technology, an engine of agricultural output growth. We include fertiliser variable along with variables of initial per ha NSDP agriculture. The coefficient of fertiliser turned out to be positive and significant with and without reforms along with other two variables, though, the REFORMS coefficient has enhanced the value of coefficient initial per ha NSDP agriculture. In Specification III of equations (i) and (ii) in Table 3, we look at the role of INSTI_CREDIT pumping to agriculture to enhance the output growth. We include the variable INSTI_CREDIT along with two additional variables. Coefficient of INSTI_CREDIT turned out to be positive and statistically insignificant. After including dummy variable for REFORMS together with three other additional variables in equation (iii) of Table 3, coefficient of REFORMS turned out to be positive but rendered INSTI_CREDIT variable statistically insignificant. Though, the REFORMS variable has enhanced the value of coefficient initial per ha NSDP agriculture. Specification IV of equations (i) and (ii) in Table 3, we look at the role of smallholders, which has been having inverse relationship between farm size and agriculture productivity. We include variable SMALLHOLDER along with three other additional variables. Coefficient of smallholder variables turned out to be positive and statically significant along with three other additional variables in

TABLE 3: DETERMINANTS OF PER HECTARE INCO ME GROWTH AND CONVERGENECE ACROSS STATES

Determinants of income growth and convergence (without reform dummy)

Variable (1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Ln PHNSDP	-0.161 (-6.33)*	-0.39 (-10.91)*	-0.405 (-10.69)*	-0.416 (-10.87)*	-0.536(-13.68)*	-0.591 (-13.91)*	-0.596 (-13.97)*	-0.61 (-14.33)*	-0.623 (-15.41)*
Ln Fertilizer		0.20 (8.51)*	0.181 (6.52)*	0.154 (4.89)*	0.123 (4.14)*	0.084 (2.63)*	0.083 (2.61)*	0.113 (3.41)*	0.051 (1.56)^
Ln INSTI_ CREDIT			0.016 (1.21)^	0.008 (0.59)	0.0046 (0.36)	-0.003 (-0.23)	-0.006 (-0.43)	0.0002 (0.02)	0.012 (0.98)
Ln Smallholding				0.0035 (1.82)***	0.0036 (2.01)**	0.002 (1.12)	0.002 (0.86)	0.004 (2.10)**	0.008 (4.03)*
Crop_ Intensity					0.009 (7.64)*	0.010 (8.03)*	0.009 (7.93)*	0.010 (8.23)*	0.006 (6.43)*
Ln R&E						0.048 (3.16)*	0.047 (3.10)*	0.056 (3.65)*	0.10 (6.21)*
Ln Roads							0.04 (1.21)^	0.034 (1.03)	0.032 (1.03)
Ln Tractors								-0.057 (-2.96)*	-0.012 (-0.59)
Diversification									-0.009 (-6.74)*
No. of observations	435	435	435	435	435	435	435	435	435
R-squared	0.26	0.22	0.22	0.23	0.32	0.34	0.34	0.36	0.42
F-statistic	40.04*	59.62*	40.27*	31.20*	40.08*	35.79*	30.92*	28.66*	33.26*

Note: *, **, ***, ^ Denote 1, 5, 10 and 20 per cent level of significance respectively.

Determinants of income growth and convergence (with reform dummy)

Variable	1	2	3	4	5	6	7	8	9
Ln PHNSDP	-0.316 (-8.57)*	-0.44 (-11.21)*	-0.45 (-11.04)*	-0.451 (-11.07)*	-0.569 (-13.82)*	-0.599 (-13.95)*	-0.604 (-14.01)*	-0.621 (-14.45)*	-0.646 (-15.89)*
Ln Fertilizer		0.171 (6.88)*	0.16 (5.62)*	0.147 (4.68)*	0.117 (3.92)*	0.087 (2.73)*	0.087 (2.71)*	0.121 (3.61)*	0.059 (1.80)***
Ln INSTI_ CREDIT			0.011 (0.83)	0.007 (0.51)	0.004 (0.28)	-0.002 (-0.17)	-0.005 (-0.37)	0.002 (1.14)	0.016 (1.29)^
Ln Smallholding				0.002 (1.10)	0.002 (1.18)	0.002 (0.82)	0.001 (0.58)	0.004 (1.86)***	0.008 (3.84)*
Crop_ Intensity					0.009 (7.66)*	0.009 (7.94)*	0.009 (7.85)*	0.010 (8.15)*	0.007 (6.16)*
Ln R&E						0.039 (2.36)**	0.039 (2.31)**	0.045 (2.72)*	0.084 (5.06)*
Ln Roads							0.040 (1.20)^	0.033 (1.00)	0.030 (0.98)
Ln Tractors								-0.062 (-3.19)*	-0.016 (-0.85)
Diversification									-0.010 (-7.27)*
Reforms	0.110 (5.63)*	0.059 (2.96)*	0.057(2.82)*	0.050 (2.37)**	0.049 (2.45)**	0.028 (1.28)	0.027 (1.27)	0.038 (1.75)***	0.065 (3.15)*
No. of observations	435	435	435	435	435	435	435	435	435
R-squared	0.15	0.24	0.24	0.24	0.34	0.34	0.35	0.36	0.44
F-statistic	37.30*	43.40*	32.70*	26.36*	34.80*	30.96*	27.30*	25.94*	31.57*

Note: *, **, ***, ^ Denote 1, 5, 10 and 20 per cent level of significance respectively.

convergence regression. All variables except INSTI_CREDIT in this specification are statistically significant. After including dummy variable for REFORMS together with other additional variables turned out to be positive and significant but rendered variables, viz., fertiliser and INSTI_CREDIT, as statistically insignificant. Though, the reforms variable has enhanced the value of coefficient per ha NSDP agriculture. In Specification V of equation (i) and (ii) in Table 3, we look at the role of cropping intensity, which has been widely reported to be important determinant of agricultural output growth. We include the variable cropping intensity (CROP_INTENSITY) along with four other additional variables. Coefficient of CROP_INTENSITY variable turned out to be positive and statistically significant along with four other additional variables. All variables except INSTI_CREDIT in this specification are statistically significant. After including dummy variable for REFORMS together with other variables, REFORMS variable turned out to be positive and significant but rendered landholding variable as statistically insignificant. Though, the REFORMS variable has enhanced the value of coefficient initial per ha NSDP agriculture. In Specification VI of equation (i) and (ii) in Table 3, we look at the role of investment in agricultural research and education as an important determinant of agricultural output growth. We include the variable R&E along with five other additional variables. Coefficient of R&E variable turned out to be positive and significant. All variables except variables, viz., small-landholders and INSTI_CREDIT in this specification are statistically significant. After including dummy variable for REFORMS together with other variables, it turned out to be positive but insignificant. Though, the REFORMS variable has enhanced the value of coefficient initial per ha NSDP agriculture. In Specification VII of equation (i) and (ii) in Table 3, we look at the role of physical infrastructure, which has been widely reported to be important determinant of agricultural output growth. We include variable ROADS along with six other additional variables. Coefficient of ROADS variable turned out to be positive and statistically significant at 20 percent level. All variables except variables, viz., total credit and small-landholders, in this specification are statistically significant. After including dummy variable for REFORMS together with other variables, it turned out to be positive and insignificant. Though, the REFORMS variable has enhanced the value of coefficient initial per ha NSDP agriculture. In Specification VIII of equation (i) and (ii) in Table 3, we look at the role of farm mechanisation, which has been widely reported as an important determinant of agricultural output growth. We include variable TRACTORS along with seven other additional variables. Coefficient of tractors variable turned out to be negative and statistically significant along with seven additional variables. After including dummy variable for REFORMS together with other additional variables in equation (ii) of Table 3, coefficient of REFORMS turned out to be positive and significant. Though, the REFORMS variable has enhanced the value of coefficient initial per ha NSDP agriculture. Specification IX of equation (i) and (ii) in Table 3, we look at the role of agriculture diversification as an important determinant of agricultural output growth.

We include variable DIVERSIFICATION along with eight other additional variables. Coefficient of DIVERSIFICATION variable turned out to be negative and statistically significant along with eight other additional variables. After including dummy variable for REFORMS together with other variables turned out to be positive and significant, and also rendered variables, viz., fertiliser, total credit, and diversification, as statistically significant. This confirms the synergy in the function of variables in unison. Though, the REFORMS variable has enhanced the value of coefficient initial per ha NSDP agriculture, in all the above specifications, the REFORMS variable has influenced convergence process. Economic reforms in the agricultural sector have induced the mobilisation of innovative technologies (like Bt cotton, single cross maize hybrid etc.) to agriculturally backward states to tap the untapped growth potential. The states where growth potential exists start releasing their inherent power of agricultural productivity in changing technologies, policies and institutions. Thus, tentatively, we infer that economic reforms have been able to cause convergence among Indian states. More precisely, economic reforms have impact on the convergence process of per ha NSDP agriculture among Indian states.

VI

CONCLUSIONS

The purpose of this paper was to investigate convergence of per hectare NSDP agriculture and catch-up among Indian states during pre-WTO, post-WTO, and whole period (1980/81-2000/10) and examined the role of agricultural conditions in this process. The growth of per hectare NSDP agricultural experience in post-reform period is very different than that of the previous decade. This shows that the growth experience during post-reform period favoured agriculturally underdeveloped states more than the other states. It turned adverse for most of the states. The growth analysis further deciphers that in both periods, the growth rate of per hectare NSDP agriculture in most of low productivity states was much lower than national average but in post-reform period, the growth rate of per hectare NSDP agriculture in most of low productivity states was higher than that of pre-reform period but also turned out to lower than the national average. Unconditional convergence shows evidence of falling regional disparities in India after WTO in 2004-05, and more so in the initial years of reforms. The tendency of divergence was stronger in pre-reform period as compared to whole period but post-reform period discerned convergence. This confirms that growth in per hectare NSDP agriculture of most agriculturally advanced states decelerated considerably and the agriculturally poor states also deciphered substantial improvement in their growth after initiation of economic reforms process. The evidence of absolute β—convergence in per hectare NSDP agriculture levels across Indian states reveals tendency of states to converge to identical steady states level. The results are in consonance with Kuznets theory of economic development. Bernard Jones method confirms that convergence is conditional. Fertiliser, public finance, smallholdings, cropping pattern, investment in agricultural research and education, physical infrastructure, mechanisation and diversification were identified factors for causing conditional convergence. All these variables generate synergy in conditioning convergence. While framing policy and designing development programmes, all these variables should be essential ingredients as policy inputs for getting desired policy outcome. Finally, the outcome of study affirms that the benefits of economic reforms started by the Government of India have shown visible impact on the convergence process of per ha NSDP agriculture among Indian states.

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NOTE

1. In 2000 three new states, viz., Uttarakhand, Chhattisgarh and Jharkhand were carved out from Uttar Pradesh, Madhya Pradesh and Bihar, respectively. Data on NSDP and other variables for these states was clubbed with their parent states.

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