Examining the Income Convergence among Indian States: Time Series Evidence with Structural Breaks

Ankita Mishra and Vinod Mishra

Mailing Address

Dr Vinod Mishra,

Department of Economics,

Monash University,

VIC – 3800, Australia.

Telephone: + (613) 99047179

E-mail: vinod.mishra@monash.edu

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ABSTRACT

This paper examines stochastic income convergence hypothesis for seventeen major states in India for the period 1960-61 to 2011-12. The KPSS stationarity and Lagrange multiplier (LM) unit root test with structural breaks and their panel versions are employed to test for income convergence hypothesis for Indian states. After taking into account the structural breaks in the series, ample evidence is found in support of stochastic income convergence in Indian states. The exercise here also highlights that the failure of other studies to find evidence on income convergence in India may result from not taking into account the potential structural breaks in the income series. The most structural breaks in relative income occur during two distinct phases of economic and political uncertainty in India; one from 1966-79 and the other from 1989-1999.

Keywords: India, panel unit root, structural break, convergence

JEL codes: O40, C12

1. Introduction

The economic growth models based on 'New Growth Theory' envisioned the poor countries/regions catching up' to rich countries/regions in levels of GDP/capita (or income per capita). These economic growth models conceived that the economies grow when the quantity of capital per hour worked increases and technological improvements take place. Since, the pay offs from using additional capital or better technology are more for a poor economy, this economy will be able to raise its growth rate at a faster rate compared to a rich economy and able to catch-up.

Various studies in the literature examined empirically 'has this catch-up or convergence actually occurred' for different groups of countries (for example, Mankiw et. al (1992), Evans (1996, 1997)) or for diverse regions (or states) within a single large country, primarily United States (for example, Young et. al (2008), Carlino and Mills (1993)). The two main techniques, used in the literature to investigate the convergence hypothesis, are cross-sectional growth equation estimations (propagated by Barro and Sala-i-Martin (1992, 1995), Mankiw et. al (1992)) and time series unit roots testing (Bernard and Durlauf (1995), Carlino and Mills (1993), Fleissig and Strauss (2001) and Strazicich et al. (2004) etc.). However, the convergence hypothesis was found to hold true for varied samples of industrial countries and their regions in the cross-sectional studies, time series evidence remained ambiguous Strazicich et al. (2004).

The notion of convergence defined as 'inclusive growth' holds pivotal place in Indian central planning. The ongoing Twelfth Five year Plan (2012-2017) acknowledges that one of the important feature of growth, relevant for inclusiveness' is more broad based sharing of high rates of economic growth across the states. Notwithstanding with objectives of central planning, regional imbalance in growth is quite acute for India. Bandyopadhyay (2011) cited that some of the richest states in India, for example, Gujarat and Maharashtra are akin to middle income countries like Poland and Brazil in their level of development while the poorest states of Bihar, Uttar Pradesh and Orissa are more analogous to that of some of the poorest Sub-Saharan African countries. The draft paper of Twelfth Five year Plan noted lessening of inter-state variation in growth rates over the Tenth (2002-2007) and Eleventh (2007-1012) five year plan period with weaker states (Bihar, Orissa, Assam, Rajasthan, Chhattisgarh, Madhya Pradesh, Uttarakhand and to some extent Uttar Pradesh) showing improvements in their growth rates and catching up. However, majority of the studies on regional economic growth in India found little support for absolute convergence[1] among Indian states and suggest increasing divergence in regional per capita income (Ghosh et. al (2013)). Hence, some of the studies examined the club convergence hypothesis[2] for Indian states and found limited support in favour of it as well (for example, Baddeley et al. (2006), Bandyopadhyay (2011) and Ghosh et. al (2013)).

Majority of the studies that examine the convergence hypothesis for India were based on cross section growth convergence equation approach[3] (Bajpai and Sachs (1996), Cashin and Sahay (1996), Nagaraj et al. (2000), Aiyar (2001) and Trivedi (2003)). Very few studies used the approach of 'stochastic convergence' to examine income convergence hypothesis for Indian states. These studies primarily concerned themselves to identify the convergence clubs endogenously (Ghosh et al (2013), Bandyopadhyay (2011) etc). Further, the studies using 'stochastic convergence' approach employed different techniques, for example stochastic kernel density techniques in Bandyopadhyay (2011) or nonlinear transition factor model in Ghosh et al (2013) and highlighted the shortcoming of previous time series approaches. Bandyopadhyay (2011), for example, pointed out that time series approaches along the lines of Carlino and Mills (1993) that estimate the univariate dynamics of income remain incomplete in describing the dynamics of the entire cross-section; Ghosh (2013) argued that unit root tests employed in stochastic convergence literature suffer from low power due to ignoring the possibility of the presence of structural breaks in the context of a single time series or in panel data framework. Addressing the concerns raised in these studies, this paper employs the latest advancements in time series approach to examine the stochastic income

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[1] The three competing hypotheses on convergence as defined by Galor (1996) are:
The absolute convergence hypothesis: per capita income of countries (or regions) converge to one another in the long run irrespective of their initial conditions; the conditional convergence hypothesis: per capita income of countries that are identical in their structural characteristics converge to one another in the long run irrespective of their initial conditions; the club convergence hypothesis: per capita income of countries that are identical in their structural characteristics converge to one another in the long run provided that their initial conditions are similar as well.

[2] Club convergence entails identifying subsets of states that share the same steady state (or clustering the income data into convergence clubs) and to check whether convergence hold within these groups (Ghosh et al (2013)). In club convergence models, one state is a leading state, called 'leader'. All countries with initial income gap less than 'certain amount' (refer to chatterjee (1992) for details) will eventually catch up with the leader. In steady state, all these countries will grow at the same rate and constitute an exclusive convergence club.

[3] Refer to Barro and Sala-i-Martin (1992, 1995); Sala-i-Martin (1996); Mankiw et al.,(1992) for details of the approach

convergence hypothesis[4] among seventeen Indian states for the period 1960-2011. This paper finds evidence in support of income convergence among Indian states, contrary to what earlier studies in the literature examining regional income convergence in India found.

This paper takes into account the some of the potential issues in using time series approach to test for regional income convergence, hence contributes to the literature significantly, most notable contributions are; First, this testing methodology is not prone to rejections of the null in the presence of a unit root with break(s), a well documented criticism against the traditional univarate unit roots tests (such as ADF and PP test). Further, with this approach the rejection of null hypothesis (of unit root) unambiguously implies stationarily in contrast to the earlier approaches of unit root tests with breaks where rejection of the null may indicate a unit root with break(s) rather than a stationary series with break(s). Second, this study employs panel versions of unit root tests with structural breaks that can exploit both the cross-sectional and time series information available in the data to evaluate the convergence hypothesis, while still allowing for the potential for structural breaks. Thus, in a situation where univariate unit root tests (with or without structural breaks) give conflicting results, overall income convergence can still be ascertained. Third, the potential problem in examining the income convergence hypothesis for states within the same country is cross-sectional dependence. This cross sectional dependence may arise due to the presence of economy wide shocks which can affect all the states (and their income) simultaneously. In order to remove cross sectional dependence, the measure of relative per capita income (per capita income of a particular state divided by the average per capita income of a group) is used. This type of transformation has been used in some of the previous studies to take care of cross sectional dependence, though in a different context (for example, Meng et. al (2013) in energy consumption; Strazicich and List (2003) in carbon dioxide emissions and Strazicich et al. (2004) in income convergence among Organization for Economic Cooperation and Development (OECD) countries). This transformation has the advantage that it removes the cross-sectional shocks that affect all the states in the panel. For example, a positive shock to

[4] The notion of stochastic convergence implies that shocks to income of a country (or region within) relative to the average income (of group of countries or regions) will be temporary. This entails testing of null hypothesis of unit root in the log of the ratio of per capita income relative to the average. Failure to reject the null of unit root suggests incomes are diverging and provide evidence against income convergence. Alternatively, rejection of null hypothesis of unit root supports income convergence. Since, the test includes a constant term stochastic convergence implies that incomes converge to a country (or region) -specific compensating differential. Hence, stochastic convergence is consistent with conditional convergence (Strazicich et al. (2004)).

per capita SDP across all the states will increase the average by the same proportion and hence leave the relative per capita SDP series unchanged implying that any structural breaks identified in the transformed series would be state specific.

The rest of the paper is organised as follows:

2. Econometric Methodology

2. 1 Conventional Unit Root Tests

To start with, this paper employs the conventional univariate unit root testing methods without structural breaks. These tests are Augmented Dickey Fuller (ADF) (Dickey and Fuller, 1979), KPSS (Kwiatkowski et al., 1992) stationarity test and LM unit root test proposed by Schmidt and Phillips (1992). The null hypothesis for ADF and LM unit root tests is that per capita income series of state $'i'$ contains a unit root. If null of unit root is accepted for per capita income series of state $'i'$, it implies shocks to income of state $'i'$relative to the average income (of group of states) will be permanent. Hence, per capita income of state $'i'$ will diverge from the average per capita income of the group. On the contrary, if the null hypothesis of a unit root in per capita income series of state $'i'$is rejected, it suggests shocks to income of state $'i'$relative to the average income (of group of states) will be transient and over the long run, per capita income of state $'i'$ will converge to the average per capita income of the group. The KPSS test differs from these two tests in its conjecture of null hypothesis. The KPSS test has the null hypothesis of (trend) stationarity against the alternative hypothesis of unit root. These tests are well documented in the literature. Therefore, the auxiliary regression equations and the limitations with these tests are not provided here[5].

2. 2 Univariate Unit Root Tests with two structural breaks

One of the potential problems with conventional unit root tests, as described above, is that these tests do not take into account the possibility of structural breaks in data series. Therefore, the power of these tests to reject the null hypothesis of unit root declines, if data series contains a unit root (Smyth, Nielsen and Mishra (2009)). Some significant events occurred in Indian economy during the periods of 1960-2011, giving rise to breaks in trend

[5] For this refer to, Smyth, Nielsen and Mishra (2009)

rate of growth of per capita income of Indian states. Therefore, ignoring the possibility of structural breaks in income series of Indian states, could lead to erroneous results.

This paper uses Lee and Strazicich (2003) LM Unit root test and Carrion-i-Silvestre and Sansó (2007) KPSS Unit root test with two endogenous breaks. The LM unit root test has the advantage over ADF-type endogenous break tests (Zivot and Andrews (1992), Lumsdaine and Papell (1997)), that it is unaffected by breaks under the null of unit root. In ADF type endogenous break unit root tests, the critical values are derived assuming no break(s) under the null. As a result, in ADF type endogenous break unit root tests, data series can be concluded as trend stationary when in reality it is non-stationary with breaks, giving rise to spurious rejection problem (Smyth, Nielsen and Mishra (2009)).

Using the notations and equations from Smyth, Nielsen and Mishra (2009), Lee and Strazicich (2003) LM Unit root test with two endogenous breaks can be explained using the following data generating process (DGP): $y_t = \delta' Z_t + e_t, \quad e_t = \beta e_{t-1} + \varepsilon_t$. Here, Z_t consists of exogenous variables and ε_t is an error term with classical properties.), Lee and Strazicich (2003) developed two versions of the LM unit root test with two structural breaks. This paper applies the most general specification that can accommodate two breaks in the intercept and the slope, is known as Model CC[6]. Model CC can be described by: $Z_t = [1, t, D_{1t}, D_{2t}, DT_{1t}, DT_{2t}]$, where $DT_{jt} = t - T_{Bj}$ for $t \geq T_{Bj} + 1, j = 1, 2,$ and 0 otherwise. T_{Bj} denotes the date when the breaks occur. Note that the DGP includes breaks under the null (β= 1) and alternative (β< 1) hypothesis in a consistent manner. Following are the null and alternative hypothesis in this model:

$$H_0 : y_t = \mu_0 + d_1 B_{1t} + d_2 B_{2t} + d_3 D_{1t} + d_4 D_{2t} + y_{t-1} + v_{1t},$$

$$H_A : y_t = \mu_1 + \gamma t + d_1 D_{1t} + d_2 D_{2t} + d_3 DT_{1t} + d_4 DT_{2t} + v_{2t},$$

Where, v_{1t} and v_{2t} are stationary error terms; $B_{jt} = 1$ for $t = T_{Bj} + 1, j = 1, 2,$ and 0 otherwise. The LM unit root test statistic is obtained from the following regression:

$$\Delta y_t = \delta' \Delta Z_t + \phi \bar{S}_{t-1} + \mu_t$$

where $\bar{S}_t = y_t - \hat{\psi}_x - Z_t \hat{\delta}_t$, $t = 2,...,T$; $\hat{\delta}$ are coefficients in the regression of Δy_t on ΔZ_t; $\hat{\psi}_x$ is given by $y_t - Z_t \delta$; and y_1 and Z_1 represent the first observations of y_t and Z_t

[6] For other versions and more technical details of the test, refer to Smyth, Nielsen and Mishra (2009)

respectively. The LM test statistic is given by: $\tilde{\tau}$ = t-statistic for testing the unit root null hypothesis that $\phi = 0$. The location of the structural break (T_B) is determined by selecting all possible break points for the minimum t-statistic as follows:

$Inf\tilde{\tau}(\bar{\lambda}_i) = \underset{\lambda}{Inf}\,\tilde{\tau}(\lambda)$, where $\lambda = T_B/T$.

The search is carried out over the trimming region (0.15T, 0.85T), where T is the sample size. We determined the breaks where the endogenous two-break LM t-test statistic is at a minimum. Critical values for this case are tabulated in Lee and Strazicich (2003).

The other Univariate unit root test, this paper implements is Carrion-i-Silvestre and Sansó (2007) KPSS stationarity test with two endogenous breaks in the intercept and trend. Following the discussion in Madsen et.al (2012), the specification for the two breaks in the intercept and trend of the time series can be given by the following equation:

$$y_t = f(t, TB_1, TB_2) + \mu_t + u_t$$

Here,

$f(t, TB_1, TB_2) = \alpha + \beta t + \theta_1 DU_{1t} + \theta_2 DU_{2t} + \gamma_1 DT_{1t} + \gamma_2 DT_{2t}$ is a deterministic specification of the time series. u_t is a stationary error term and μ_t is a random walk process, represented as:

$$\mu_t = \mu_{t-1} + \varepsilon_t$$

Where $\varepsilon_t \sim iid(0, \sigma_\varepsilon^2)$. The null hypothesis of stationarity is $\sigma_\varepsilon^2 = 0$. As ε_t is assumed to be stationary, under the null hypothesis y_t is trend-stationary. A special case of this would be the one in which β is set as $\beta = 0$, in which case under the null hypothesis y_t is stationary around a level rather than around a level and a trend. DU_{1t}, DU_{2t}, DT_{1t} and DT_{2t} are dummy variables created to incorporate the presence of structural breaks. The dummy variables are defined by the following general form:

$$DU_{i,t} = 1, DT_{i,t} = (t - TB_i) \text{ if } t > TB_i \text{ and 0 otherwise}$$

Where $TB_i = \lambda_i T$, such that $\lambda_i \in (0,1)$, and $i = 1,2$.

The KPSS test statistic with two structural breaks for deterministic specification is given as:

$KPSS = \hat{\sigma}^{-2} T^{-2} \sum_{t=1}^{T} S_t^2$

Where $S_t = \sum_{i=1}^{t} \hat{e}_{i,}$ with $\hat{e}_i$, being the OLS estimated residual of the regression of y_t on the deterministic specification. The long-run variance is estimated by:

$$\hat{\sigma}^2 = T^{-1}\sum_{t=1}^{T}\hat{e}_t^2 + 2T^{-1}\sum_{s=1}^{l} w(s,l) \sum_{t=s+1}^{T}\hat{e}_t\hat{e}_{t-s}$$

Where $w(s,l)$ denotes either the Bartlett or the Quadratic spectral window. This paper used the Bartlett kernel and the bandwith was selected using the Andrews method[7]. The break dates are estimated by minimization of the sequence of sum of squared residuals (SSR) proposed by Kurozumi (2002). This procedure chooses the dates of the breaks from the argument that minimizes the sequence of $SSR(TB_1, TB_2)$, where the SSR is obtained from the regression of $y_t = f(t, TB_1, TB_2) + e_t$, such that $f(t, TB_1, TB_2)$ denotes the deterministic specification. More specifically the break points are estimated by the following minimization equation:

$$\left(\widehat{TB}_1, \widehat{TB}_2\right) = \arg\ \min_{\lambda_1,\lambda_2 \in \Lambda} SSR(TB_1, TB_2)$$

where Λ denotes a closed subset of the interval $(0,1)^2$. In order to minimize the information loss, Λ was defined as $\Lambda = \left[\frac{2}{T}, \frac{T-1}{T}\right]^2$.

2.3 Panel unit root tests with structural breaks

This paper implements the panel KPSS stationarity test with multiple breaks (Carrion-i-Silvestre et al, 2005)[8]. This test has the null of stationarity, hence takes into account the criticism by Bai and Ng (2004) that for many economic applications it is more natural to take stationarity as the null hypothesis, rather than non-stationarity. It allows for structural shifts in the trend of the individual time series in the panel and permits each state in the panel to have a different number of breaks at different dates. In addition to the panel test statistic, the Carrion-i-Silvestre et al's (2005) test produces results for individual time series in the panel.

Carrion-i-Silvestre et al's (2005) test is a generalization for the case of multiple changes in level and slope of the panel stationarity test of Hadri (2000), which is computed as the average of Univariate KPSS stationarity tests. The distinguishing feature of this test is that it only produces the statistically significant breaks. To estimate the break dates, Carrion-i-

[7] While the results are reported in this paper using the Bartlett kernel, these results are also estimated using the Quadratic kernel and the results were not sensitive to the choice of kernel.

[8] The details on the features of Carrion-i-Silvestreetal., 2005 test is mainly borrowed from Madsen et. al 2012

Silvestre et al. (2005) apply the Bai and Perron (1998) technique. Trimming is necessary when computing estimates of break dates. The trimming region used here is $T[0.1, 0.9]$. Once all possible dates are identified, Carrion-i-Silvestre et al. (2005) recommend that the optimal break dates be selected using the Liu et al. (1997) modified Schwartz Information Criterion (SIC) for trending regressors. This method involves sequential computation and detection of the breaks using a pseudo F-type test statistic. The Carrion-i-Silvestre et al. (2005) test allows for a maximum of five structural breaks (Madsen et. al (2012)).

In addition to Carrion-i-Silvestre et al's (2005) test, this paper also computes panel LM unit root tests with structural breaks (IM et al (2005)) as a robustness check. Unlike the Carrion-i-Silvestre et al's (2005) test, this test has the null hypothesis of panel unit root suggesting that per capita incomes of Indian states are not converging[9].

3. Data and Results

3.1 Data Description

The data used are per capita net state domestic product (NSDP) for seventeen major states of India for the period 1960-61 to 2011-12. This data were collected from *Indiastat* database. These per capita net state domestic products for seventeen major were expressed in Indian Rupees (Rs.) and provided at different base periods. All the series are converted to the common base period of 2004-05[10].

Descriptive statistics on NSDP per capita is reported for the full sample period in Table 1. More than half of the states (nine out of seventeen) have average annual per capita income below Rs. 10,000 with Bihar (preceded by Uttar Pradesh, Assam, Madhya Pradesh, Orissa, Manipur, Rajasthan, Tripura and West Bengal) at the bottom of the list; three states (Haryana, Maharashtra and Punjab) have average annual per capita income above Rs. 15,000 and the remaining five states (Gujarat, Tamil Nadu, Kerala, Karnataka and Andhra Pradesh) have average annual per capita income between Rs. 10,000 to Rs. 15,000 for the period 1960-61 to 2011-12. Fluctuations in per capita income around the mean (as measured by standard deviation) are in line with the ranking of states on income with Haryana displaying the highest fluctuations and Bihar showing the lowest variations. NSDP per capita series for all

[9] For details on this test, refer to Smyth, Nielsen and Mishra (2009)
[10] The latest base period used for compiling the net state domestic products

the states are positively skewed indicating that the future values of NSDP per capita are more likely to be higher than the mean.

INSERT TABLE 1 HERE

This paper has taken the measure 'relative per capita income' to examine the convergence hypothesis. For this, NSDP per capita of state $'i'$ is converted to its relative NSDP per capita in the following way:

$$Relative\ Per\ Capita\ NSDP_{it} = ln\left(\frac{PerCapita\ NSDP_{it}}{Average\ Per\ Capita\ NSDP_t}\right)$$

All the analysis is conducted on this transformed series. If this relative per capita NSDP is found to be stationary, this would mean that per capita NSDP among seventeen Indian states is converging. As mentioned earlier, this transformation has the advantage that it removes the cross-sectional shocks that affect all the states in the panel. Therefore, any structural breaks identified in the transformed series would be state specific (Mishra and Smyth (2014)).

In order to test the effectiveness of this transformation in removing the cross-sectional dependence, Pesaran (2004) cross-sectional dependence (CD) test on the per capita NSDP series is conducted, before and after transforming it into relative per capita NSDP. The purpose of this test was to ascertain that results of analysis are not driven by some kind of cross-sectional dependence in the data and the method of transforming per capita series as a ratio of average per capita incomes is capable of removing cross-sectional dependence from the data. The null hypothesis in CD test is that the series are cross-sectionally independent. The results are reported in Table 2. The top panel reports the results for the untransformed series. It is noted that the Pesaran CD statistic is highly significant at all the 4 lags, implying a strong rejection of the null of cross-sectional independence. The bottom panel reports CD statistics for the transformed series, where the null of cross-sectional independence cannot be rejected, even at 10 per cent. These results suggest that cross-sectional dependence was present in the series; however, it is adequately removed by transforming each series into relative per capita SDP.

INSERT TABLE 2 HERE

3.2 Results

As a benchmarking exercise, three tests, namely, the ADF Schmidt and Phillips LM unit root test and KPSS stationarity test without structural breaks are carried out. The results for these are reported in Table 3. The ADF unit root test is simplest of all and all the other future tests are improvement over this test. The results for this test suggest that the null of unit root cannot be rejected in any of the transformed series at the traditional levels of significance, suggesting no evidence of convergence in per capita incomes. Second test, is KPSS test, in which the null hypothesis is stationarity. Third test is Schmidt and Phillips Lagrange multiplier based test, in which the null hypothesis is unit root[11]. In the KPSS test, the null of stationarity is rejected for 11 out of 17 series and in Schmidt and Phillips LM test fail to reject null of unit root in 13 out of 17 cases. The overall conclusion that seems evident, based on these tests results is that, there is no indication of convergence in per capita incomes for Indian states in the sample.

INSERT TABLE 3 HERE

Table 4 presents the results of LM unit root tests and KPSS stationarity tests with two endogenous breaks in the intercept and slope. Lee and Strazicich (2003) LM Unit root test is a Lagrange multiplier based test with null hypothesis of unit root in the series. The most general specification of the test that allows for two breaks in the intercept as well as trend (Model CC) of the series is estimated. In this test the null hypothesis of unit root is rejected by looking at the LM parameter and the presence of significant structural breaks is determined by looking at the significance of the dummies for breaks in intercept and trend. The full test results of this test give the LM test statistics, as well as the coefficients and significance of dummies for break in trend and intercept for the break dates endogenously determined by the test. In the above table, however, only he LM test statistics and the break dates identified by the test are reported. In terms of the significance of the break dates, it is found that in most of the case both the dummies (break in intercept and break in trend) were significant and at least one dummy was significant at each break date reported. After taking into account the occurrence of structural breaks in the series, the null of unit root in relative per capita NSDP series is rejected for 10 states (58.8% of the sample) at 5% level of significance or better and 12 states (70.5% of the sample) at 10% level or better for LM unit root test. Comparing these results with the ones reported in Column 3 of Table 2 (Schmidt

[11] These tests are reported as benchmark results here. Their modified versions with unit structural breaks are used in the main analysis of this paper.

and Philips LM Unit root test), it is noted that the number of states for which the null of unit root can be rejected increases dramatically to 12 out of 17 compared to 4 out of 17, when the structural breaks weren't allowed in the data.

The second test presented in this table is Silvestere and Sanso (2007) KPSS test with two structural breaks. This is a test based on the KPSS test, which allows for two breaks in the series and has a null hypothesis of stationarity. It uses a BIC criterion two select the two significant breaks over the entire set of break-point combinations. The results of this test compare with the KPSS test results reported in Table 2 Column 2, which uses the same methodology but does not allows for structural breaks in the data. The results of this test more strongly support the convergence hypothesis. The KPSS test fails to reject the null hypothesis of stationarity for 15 states (88.2% of the sample) at the 5 per cent level and for 13 states (76.4% of the sample) at 10 per cent level or better. These test results point to the considerable, though not universal, evidence of convergence in per capita incomes of Indian states. Overall, based on the univariate LM unit root and KPSS stationary test with two breaks in the intercept and trend, support for per capita income convergence is found for all states except West Bengal.

INSERT TABLE 4 HERE

After accounting for structural breaks in the individual relative income series, majority of the states exhibit convergence in per capita NSDP towards the group average. However, for few of the states the convergence of income does not found to be holding true. Therefore, the next logical step was to check the stationarity of the overall panel of the relative incomes of Indian states. The stationarity of the whole panel would mean, that the overall evidence in favour of convergence of incomes outweighs the evidence against convergence.

The panel unit root test results for Hadri(2000) test – without structural breaks, Carrion-i-Silvestre et al. (2005) – with a maximum of five structural breaks and Im et al (2005) LM unit root test – with zero, one and two structural breaks are reported in Table 5. Hadri (2000) and Carrion-i-Silvestre et al. (2005) tests are reported with alternative assumptions that the long-run variance is homogeneous or heterogeneous. It was found that the null hypothesis of stationary is not rejected in any of the cases, which implies that there is a strong evidence of mean-reversion in the panel of relative incomes. This result is robust to the alternative assumptions about the variance and the presence/number of structural breaks in the data. The same results is confirmed by the Panel LM unit root test by Im et al (2005), reported in lower half of Table 5. The null hypothesis in this case is unit root, and the test was conducted with alternate specifications of zero, one and two structural breaks in the individuals data series. It was noted that the null hypothesis of unit root is rejected at the traditional levels of significance in all the specifications, suggesting a strong definitive evidence of convergence in per-capita incomes for the overall panel.

INSERT TABLE 5 HERE

4. Structural Breaks

The dates of structural breaks in relative per capita NSDP of states, as reported in Table 4, can be linked to significant political, economic and environmental events occurred regionally or nationally in India. It is noted that for majority of the states except Bihar, Gujarat and Tripura, the first structural break in relative income occurred during the period of 1966-1979. This period is characterized by some major upheavals. India experienced three economic crises during this period, one in 1965-66, second in 1973-74 and third in 1979-80. All these three crises were predominantly the balance of payment crisis, which were caused by the shortage of food grains triggered by droughts and further aggravated by the extraneous factors, like wars (wars with Pakistan in 1965 and 1971) and international oil crisis of 1973 and 1979. For Bihar and Gujarat, the first structural break occurs in early 1990s. This can be associated with the political regime shift in both of these states. Congress party largely ruled these states since independence. However, in 1990 the power shifted from Congress party to Bhartiya Janata Party (BJP) in Gujarat and Janata Dal (JD) in Bihar. Since then Congress party never got elected again in these states.

The second structural break in relative income for most of the states except Bihar, Gujarat and Orissa occurred during the period of 1989-1999. This period again is marked with some significant political and economic incidents in India. Following a tumultuous period since 1965 to 1980, Indian economy witnessed a turn around and experienced high growth in the decade of eighties. However, this period of development also characterized with unsustainable level of government spending, resulting in mounting internal and external debt and expenditure on subsidies giving rise to severest balance of payment crisis in India in

1991. On the political front, former ex-prime minister, Mr. Rajiv Gandhi was assassinated in May, 1991 by Liberation Tigers of Tamil Eelam /(LTTE), a militant organization from Sri Lanka. This incident had provoked anti Tamil violence in India mainly affecting the state of Tamil Nadu. On an international front, Iraqi invasion of Kuwait in August 1990 resulted in sharp increase in the international price of oil. Because of all the above-mentioned events taking place nationally and globally, Indian economy witnessed a very acute macroeconomic crisis, the like of which it had never faced in the past. As a result, Indian government initiated a major programme of structural and economic reforms in 1991 bringing about significant policy changes in external, financial and industrial sectors.

Indian economy experienced a period of political uncertainty during 1996 to 1999, characterised by three general elections in three years. India also faced a brief period of War with Pakistan in 1999, known as Kargil War and short-lived phase of economic sanctions by United States as a fall out of 1998 nuclear tests. This period of political turmoil and uncertainly ended in 1999, when National Democratic alliance (NDA), a coalition of 20 parties, headed by Bhartiya Janata Party (BJP), managed to secure majority and formed the government that completed its full term.

From the discussion above, it seems evident that most structural breaks in relative income occur in India during two distinct phases of economic and political uncertainty in India; one from 1966-79 and the other from 1989-1999. The presence of these structural breaks carries significant implications for our findings. As pointed out by Strazicich et al. (2004), the proper detection of these structural breaks increases the ability to reject the null hypothesis of unit root and the state specific conditioning variables (such as infrastructure/ investmment expenditure, as measured by irrigation, electrification and railway track building expenditure in Bandyopadhyay (2011) or Baddeley et al. (2006)) can be permanently altered following a major shock, hence altering the time path of relative income permanently. Not taking into account these structural breaks in the analysis seems the reason that earlier studies on state income convergence in India could not find an evidence of stochastic convergence. Some of the studies (for example Baddeley et al. (2006)) found empirical evidence in support overall income divergence in states of India while others (like Ghosh et.al (2013)) could find some evidence only in support of club convergence.

5. Conclusion

Using latest advancements in time series techniques, this paper examines the stochastic income convergence hypothesis for seventeen Indian states for the period 1960-61 to 2011-12. The testing methodology, used in this paper, endogenously determines two breaks in the level and trend of the series. This testing methodology take care of the potential problem with traditional unit root tests of biased conclusions in the presence of structural breaks i.e. commit a type 2 error of identifying the series as non-stationary when its actually stationary with one or more structural breaks. It is found that while unit root tests without structural breaks do not indicate income convergence hypothesis to hold true for Indian states, the tests with structural breaks provide significant evidence in support of stochastic income convergence for Indian states. The structural breaks identified in income series of Indian states often occur in time periods 1966-79 and 1989-1999. These periods are also characterized by incessant economic crisis and political uncertainty in India. The earlier studies on income convergence in India do not take into account the presence of these breaks in income series of the states; therefore find little or no evidence in support of income convergence in Indian states. In addition the panel version of unit root test with structural breaks is also used to find out the overall convergence of the per capita SDP among Indian states. While it is found that, univariate tests with structural breaks found income convergence hypothesis to hold true for roughly about the 88% of states in the sample, panel version of unit root tests establish that incomes of Indian states as a group are overall converging.

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Tables and Figures

Table 1: Descriptive statistics of SDP per capita (in Indian Rupees) for the sample period (1960 – 2011) for 17 major Indian states

Series	Observations	Mean	Std. Dev.	Min.	Max.	Skewness
Andhra Pradesh	52	11275.19	16857.03	315.82	71540.00	2.01
Assam	52	7213.92	8590.57	394.60	33633.00	1.45
Bihar	52	4151.55	5360.34	245.03	24681.00	2.09
Gujarat	52	14335.27	20442.27	435.54	86681.00	1.91
Haryana	52	16923.69	25215.94	381.63	109227.00	2.07
Karnataka	52	11918.28	16848.50	373.24	69493.00	1.84
Kerala	52	13467.08	19313.44	373.22	80924.00	1.85
Madhya Pradesh	52	7322.86	9014.46	337.89	37994.00	1.62
Maharashtra	52	16348.39	23559.71	460.90	101314.00	1.95
Manipur	52	7684.20	8867.30	203.63	32865.00	1.21
Orissa	52	7640.99	10484.25	274.71	41896.00	1.83
Punjab	52	15156.74	19244.88	406.93	74606.00	1.55
Rajasthan	52	8884.66	11917.98	387.74	53735.00	1.95
Tamil Nadu	52	13718.52	20192.95	430.18	84496.00	1.95
Tripura	52	9505.33	12810.55	368.94	50175.00	1.63
Uttar Pradesh	52	6084.67	7339.68	307.32	30051.00	1.57
West Bengal	52	9777.45	13081.23	451.75	54830.00	1.78

Table 2. Cross-section correlation of the errors in the ADF(*p*) regression for SDP per Capita for the 17 Major Indian states.

	P=1	P=2	P=3	P=4
Panel A = Actual SDP per capita				
$\bar{\hat{\rho}}$	0.324	0.239	0.230	0.236
CD	26.177***	19.288***	18.550***	19.083***
Panel B = Relative SDP per capita [ln(SDP per capita in state i/Average SDP per capita)]				
$\bar{\hat{\rho}}$	-0.046	-0.045	-0.039	-0.037
CD	-3.743	-3.632	-3.152	-2.982

Notes: The cross-sectional dependence (CD) test statistic is proposed in Pesaran (2004) for testing for cross sectional dependence in panels. All statistics are based on univariate AR(*p*) specifications in the level of the variables with $p \leq 4$. The null hypothesis is that output innovations are cross-sectionally independent. The 10%, 5% and 1% critical values for the CD statistic are 1.64, 1.96 and 2.57 respectively.

Table 3: Results of Univariate unit root tests without structural breaks

Series	ADF Test	KPSS Test	Schmidt and Philips LM Unit root test
Andhra Pradesh	-0.348	0.236***	-1.753
Assam	-0.278	0.134*	-1.578
Bihar	-0.865	0.110	-1.703
Gujarat	-1.998	0.078	-5.553***
Haryana	-1.245	0.120*	-2.443
Karnataka	-1.608	0.210**	-2.907*
Kerala	-0.776	0.161**	-2.128
Madhya Pradesh	-0.872	0.199**	-2.419
Maharashtra	-0.669	0.064	-2.107
Manipur	-1.865	0.243***	-1.322
Orissa	-2.182	0.068	-2.157
Punjab	-1.889	0.217***	-0.966
Rajasthan	-2.364	0.059	-3.949***
Tamil Nadu	-0.360	0.204**	-0.839
Tripura	-2.258	0.086	-2.593
Uttar Pradesh	0.501	0.194**	-1.416
West Bengal	-1.515	0.134*	-3.170*

Notes: Sample consisted of annual data for the period 1960 - 2011. The unit root tests were preformed on the series

$$y_{it} = \ln\left(\frac{SDP\ Per\ Capita_{it}}{Average\ SDP\ Per\ Capita_t}\right)$$

with the assumption of an intercept and trend in the series. The lag lengths were selected using the Bayesian Information criteria (BIC). The null hypothesis for ADF and LM test is a unit root, whereas the null hypothesis for the KPSS test is stationarity. The critical values for each test are as follows:

Test	Critical Values		
	1%	5%	10%
ADF	-3.58	-2.93	-2.60
KPSS	0.216	0.146	0.119
Schmidt and Philips	-3.73	-3.11	-2.80

Table 4: Results for Univariate unit root tests with two structural breaks

	Lee and Strazicich (2003) LM Unit root test			Carrion-i-Silvestre and Sansó (2007) KPSS Unit root test.		
Series	**Test statistic**	**TB1**	**TB2**	**Test statistic**	**TB1**	**TB2**
Andhra Pradesh	-6.932***	1979	1992	0.020	1974	1987
Assam	-5.269	1979	1992	0.033	1972	1983
Bihar	-6.716***	1990	2007	0.057*	1983	2004
Gujarat	-7.026***	1993	2001	0.039	1993	2001
Haryana	-6.390**	1978	1996	0.047	1968	1996
Karnataka	-4.969	1975	1989	0.044	1966	1975
Kerala	-5.428*	1987	1998	0.037	1967	1993
Madhya Pradesh	-6.276**	1987	2004	0.034	1966	1986
Maharashtra	-4.806	1972	1998	0.022	1973	1988
Manipur	-6.067**	1990	2005	0.045	1968	1986
Orissa	-5.855**	1979	2002	0.087**	1979	2002
Punjab	-5.466*	1971	1996	0.024	1979	1991
Rajasthan	-6.037**	1978	1998	0.030	1978	1999
Tamil Nadu	-4.985	1979	1994	0.028	1973	2000
Tripura	-6.550***	1988	1999	0.091**	1991	2000
Uttar Pradesh	-6.413***	1969	1989	0.033	1967	1989
West Bengal	-5.119	1980	1995	0.065*	1983	1996

Notes: Both the tests were performed under the assumption of break in Intercept and Trend. TB_1 and TB_2 are the dates of the structural breaks. λ_j denotes the location of the breaks. For the LM unit root test the null distribution of the LM test depends on the relative location of the breaks. The critical values for LM unit root test are presented in the table below. The 10%, 5% and 1% critical values for Carrion-i-Silvestre and Sansó (2007) KPSS Unit root test are 0.0552, 0.0665 and 0.0936 respectively. The *, **, *** denotes statistical significance at the 10%, 5% and 1% levels respectively.

Critical values for LM unit root test (S_{t-1})									
Model CC (Break in Intercept and Trend)									
λ_2		0.4			0.6			0.8	
λ_1	1%	5%	10%	1%	5%	10%	1%	5%	10%
0.2	-6.16	-5.59	-5.27	-6.41	-5.74	-5.32	-6.33	-5.71	-5.33
0.4	-	-	-	-6.45	-5.67	-5.31	-6.42	-5.65	-5.32
0.6	-	-	-	-	-	-	-6.32	-5.73	-5.32

Table 5: Results of Panel Unit root tests.

Hadri (2000) and Carrion-i-Silvestre et al. (2005) KPSS tests				
Panel of 17 States	KPSS test statistic (Using Bartlett kernel)	Bootstrap critical values		
		10%	5%	1%
No Breaks (Homogenous)	1.224	3.69	4.89	7.56
No Breaks (Heterogeneous)	2.016	3.73	4.63	6.16
Breaks (Homogenous)	8.042	8.74	9.74	11.73
Breaks (Heterogeneous)	14.455	17.01	18.55	21.19
IM et al (2005) Panel LM Unit root tests				
Panel of 17 States	Panel LM test statistic			
No Breaks	-3.075***			
One Break	-9.412***			
Two Breaks	-12.431***			

Notes: (1.) ** and *** denotes significance at the 5% and 1% levels, respectively. (2.) Bootstrap critical values for Hadri (2000) and Carrion-i-Silvestre et al. (2005) KPSS tests are based on a Monte Carlo simulation with 20,000 replications. (3.) The 1, 5 and 10% critical values for the IM et al (2005) panel LM unit root tests are -2.236, -1.645 and -1.282 respectively.