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PAPER

"Are Shocks to Real Output Permanent or Transitory?" Evidence from a Panel of Indian States and Union Territories

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Abstract Mean reversion properties of per capita SDP of 31 Indian states and Union territories have been analyzed using panel unit root test assuming cross sectional independence among Indian states and later relaxing this assumption. The first generation panel unit root test assuming cross sectional independence shows that Indian per capita GDP data contains unit root. The second generation panel unit root test, relaxing the cross sectional independence assumption, also provides no evidence for mean reversion (stationarity) of Indian per capita GDP. Our results indicate that Indian output data is not reverting back to the natural rate and stabilization policies are required to bring the economy to the equilibrium path.

Keywords India - Mean reversion - Panel Unit root test - Per capita GDP - Unit root

JEL Classification E - E3 - E32 - C23

Introduction

Theoretically Neo-Keynesian and Monetarist economists assume that the business cycles are transitory phenomena, and output returns to its innate rate in long run. Therefore, if we found unit root in output data, it is against the natural rate hypothesis predicted by the traditional economic theory and implies that real variables such as technology shock have role in economic fluctuations. Further the evidence of presence of unit root in real variables provides evidence for the relevance of stabilisation policies suggested by Keynes. Presence of unit root implies that the output variable is not returning to the natural rate after shocks and the stabilisation policies are required to control the economy. On the contrary, absence of unit root implies that the output variable is returning to the natural rate and the stabilisation policies will have temporary effect on the variable of interest (Libanio 2005). Nelson and Plosser (1982) was the first study in this area using US macroeconomic data and they observed that "real shocks associated with the secular component contribute substantially to the variation in observed output, and either these shocks are correlated with the innovations in the cyclical component or the secular component contains transitory fluctuations (or both)" (page 141). Many authors have extended the study of Nelson and Plosser by using different unit root methodologies and data.

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The current study is an attempt to examine the mean reversion properties of the per capita State domestic Product (hereafter PSDP) of 31 Indian states and/ or union territories using the first and second generation panel unit root test. The mean reversion properties of the Indian PSDP have not studied much in the literature. Here we are attempting to study this in panel framework. Panel unit root tests are popular since it is found that univariate unit root tests suffer from low power and the possible way to increase the power of the test is to exploit cross-section variation together with univariate time series dynamics see Quah, 1994; Levin et al., 2002 quoted in Costantini and Claudio (2011)).

The rest of the paper is structured as follows. The following section provides an overview of the data and in the next section we narrate the various panel unit root tests we used in this study, followed by the interpretation of results. The policy implications of the study are considered in the conclusion section of the paper.

Data and Variables

We used the PSDP data of 31 Indian states or union territories for the period 1992-1993 to 2009-2010 from the "*Data Base on Indian Economy"* maintained by the Reserve bank of India (RBI). We have used data for 27 states and 4 union territories (UTs). States included are Andhra Pradesh, Arunachal Pradesh, Assam , Bihar, Jharkhand, Goa, Gujarat, Haryana, Himachal Pradesh , Jammu and Kashmir, Karnataka, Kerala, Madhya Pradesh , Chhattisgarh, Maharashtra, Manipur, Meghalaya ,Nagaland, Odisha, Punjab, Rajasthan, Sikkim, Tamil Nadu, Tripura, Uthar Pradesh, Uttarakhand, West Bengal and the union territories(UTs) are Andaman & Nicobar Islands, Chandigarh, Delhi and Puduchery. Since data for the new states such as Uttarakhand, Jharkhand and Chhattisgarh are available only from 1992-93 onwards we have selected the period 1992-1993 to 2009-2010, the data for Mizoram is not available for the entire study period, therefore barred.

First and Second Generation Panel unit root tests

Panel unit root tests are admired since the univariate unit root tests suffer from low power and the possible way to increase the power of the test is to exploit cross-section variation together with univariate time series dynamics. (See Quah, 1994; Levin et al., 2002 quoted in Costantini and Claudio (2011)). Costantini and Claudio (2011) observed that apart from the increasing power, panel unit root tests are useful to avoid complications arising from multiple testing using the univariate tests and more suitable when the "focus is on testing for the presence of a unit root as an interesting and economically interpretable common feature in a whole set of time series" (page 1).

We used both first generation and second generation panel unit root tests to examine the mean reversion properties of Indian PSDP data. The first generation tests assume cross section the independence, as the second generation tests relaxes this assumption and assumes cross section dependence. Among the first generation tests, we used LLC test (Levin-Lin-Chu (2002), IPS test (Im, Pesaran and Shin 2003) , ADF - Fisher Chi-square (Maddala and Wu, 1999 (hereafter MW test)) and PP - Fisher Chi-square tests(Choi, 2001(hereafter Choi test)). Among these LLC test assumes that the mean reversion coefficient are common across states or UTs ($\rho=\rho_i$).

However, the other three tests, ie. IPS test (Im, Pesaran and Shin 2003) , ADF - Fisher Chi-square and PP - Fisher Chi-square tests relax this assumption and allow individual unit root process (allowing ρ_i to vary across states or UTs). So in these three cases the null of unit root is tested against the alternative hypothesis of some individuals without unit roots.

In LLC tests we derive the estimates of ρ from proxies for ΔY_{it} and Y_{it} that are standardized and free of autocorrelations and deterministic components
The LLC test employs the following adjusted t-statistic:

$$t_{\hat{\partial}}^{*} = \frac{t_{\alpha} - (NT)\hat{S}_{N}\sigma_{\tilde{\varepsilon}}^{-2}\sigma_{\hat{\alpha}}\mu_{T}^{*}}{\sigma_{T}^{*}} \quad (1)$$

where $\hat{s}_N$ is the average of individual ratios in the long-run to short-run variance for state/UT i;

$\sigma_{\tilde{\varepsilon}}$ is the standard deviation of the error term in equation (2); $\sigma_{\hat{\alpha}}$ is the standard deviation of the slope coefficients in equation (2); σ_T^* is the standard deviation adjustment; μ_T^* is the mean adjustment.
The IPS test, MW tests and Choi tests allow ρ_i to vary across cross sections. In these entire tests individual unit root test are combined to derive the panel results. The IPS test employed a standardized t_bar statistic that is based on the movement of the Dickey–Fuller distribution:

$$Z_{t\_bar} = \frac{\sqrt{N}\{t\_bar - N^{-1}\sum_{i=1}^{N} E(t_{iT})\}}{\sqrt{N^{-1}\sum_{i=1}^{N} Var(t_{iT_i})}} \quad (2)$$

Where $E(t_{iT})$ is the expected mean of t_{iT}, and $Var(t_{iT_i})$ is the variance of t_{iT}.
The MW test (Maddala and Wu 1999) is based on the combined significance levels (p-values) from the individual unit root tests. According to Maddala and Wu (1999), if the test statistics are continuous, the significance levels π_i (i =1, 2, ….N) are independent and uniform (0,1) variables. The MW test uses combined p-values, or P_{MW}, which can be expressed as:

$$P_{MW} = -2\sum_{i=1}^{N} \log \pi_i \quad (3)$$

where $-2\sum \log \pi_i$ has a χ^2 distribution with the 2N degree of freedom. Furthermore, Choi (2001) suggested the following standardized statistic:

$$Z_{MW} = \frac{\sqrt{N}\{N^{-1}P_{MW} - E[-2\log(\pi_i)]\}}{\sqrt{Var[-2\log(\pi_i)]}} \quad (4)$$

Under the cross-sectional independence assumption, this statistic converges to a standard normal distribution (Hurlin 2004).

Among the second-generation unit root tests, this paper used: a) the MP test (Moon and Perron 2004) b) the Pesaran test (Pesaran 2007) and c) the Choi test (Choi 2006). Moon and Perron (2004) use a factor structure to model cross-sectional dependence. Their model assumes that error terms are generated by r common factors and idiosyncratic shocks.

$$y_{it} = \alpha_i + y_{it}^{0} \quad (5)$$

$$y_{it}^{0} = \rho_i y_{it-1}^{0} + \upsilon_{it} \quad (6)$$

$$\upsilon_{it} = \lambda_i^{'} F_t + e_{it} \quad (7)$$

Where F_t is a r×1 vector of common factors and λi is a vector of factor loadings. The idiosyncratic component e_{it} is assumed to be i:i:d: across i and over t. The null hypothesis corresponds to the unit root hypothesis H0: $\rho_i = 1$; where i = 1, …, N whereas under the alternative the variable y_{it} is stationary for at least one cross-sectional unit. For testing, under the data are de-factored and then the panel unit root test statistics based on de-factored data are proposed.
Moon and Perron treat the factors as nuisance parameters and suggest pooling de-factored data to construct a unit root test. The intuition is as follows. In order to eliminate the common factors, panel data are projected onto the space orthogonal of the factor loadings. By doing this, the de-factored data and its residual do not retain cross-sectional dependencies. This allows us to define standard pooled t-statistics, as in IPS, and to show their asymptotic normality. Following the above let $\hat{\rho}^{+}_{pool}$ pool be the modified pooled OLS estimator using the de-factored panel data. Then, Moon and Perron (2004) define two modified t-statistics, which have a standard normal distribution under the null hypothesis:

$$t_\alpha = \frac{T\sqrt{N}\left(\rho^{+}_{pool} - 1\right)}{\sqrt{2\gamma_e^4 / w_e^4}} \xrightarrow[T,N\to\infty]{d} N(0,1) \tag{8}$$

$$t_b = T\sqrt{N}\left(\rho^{+}_{pool} - 1\right)\sqrt{\frac{1}{NT^2} trace\left(Z_{-1} Q_{\wedge} Z'_{-1}\right)\frac{w_e^2}{\gamma_e^4}} \xrightarrow[T,N\to\infty]{d} N(0,1) \tag{9}$$

where w_e^2 denotes the cross-sectional average of the long-run variances $w_{e_i}^2$ of residuals e_{it} and γ_e^4 denotes the cross-sectional average of $w_{e_i}^4$. Moon and Perron (2004) propose feasible statistics t_α^* and t_b^* based on an estimator of the projection matrix and estimators of long-run variances $w_{e_i}^2$.
Im Pesaran's test, the augmented Dickey-Fuller (ADF) regressions are augmented with the cross-sectional average of lagged levels and first-differences of the individual time series (Pesaran, 2007). This allows the common factor to be proxies by the cross-section mean of y_{it} and its lagged values. The Pesaran test uses cross-sectional augmented ADF statistics, (denoted as CADF), which are given below:

$$\Delta y_{i,t} = \alpha_i + b_i y_{i,t-1} + c_i \bar{y}_{t-1} + d_i \Delta\bar{y}_i + e_{i,t} \tag{10}$$

where a_i, b_i, c_i, and d_i are slope coefficients estimated from the ADF test in country i; $\bar{y}_{t-1}$ is the mean value of lagged levels, and $\Delta\bar{y}_i$ is the mean value of first-differences; $e_{i,t}$ is the error term. Pesaran (2007) suggested modified IPS statistics based on the average of individual CADF, which is denoted as a cross-sectional augmented IPS (CIPS). This is estimated from:

$$CIPS = \frac{1}{N}\sum_{i=1}^{N} t_i(N, T) \tag{11}$$

where t (N, T) is the t-statistic of the OLS estimate of in equation (5). The next test in this study is the Choi test based on the statistic that combines p-values from ADF tests in which their non-stochastic trend components and cross-sectional correlations are eliminated using the Elliott, Rothenberg and Stock's GLS-based de-trending and the conventional cross-sectional demeaning for the panel data (Choi, 2006). It is called the Dickey-Fuller-GLS statistic. Based on this statistic, Choi (2006) suggested the following Fisher's type statistics:

$$P_m = -\frac{1}{\sqrt{N}}\sum_{i=1}^{N}[\ln(P_i) + 1] \tag{12}$$

$$Z = \frac{1}{\sqrt{N}}\sum_{i=1}^{N}\Phi^{-1}(P_i) \tag{13}$$

$$L^* = \frac{1}{\sqrt{\pi^2 N/3}}\sum_{i=1}^{N}\ln(P_i/1 - p_i) \tag{14}$$

Where is the p-values of the Dickey-Fuller-GLS statistic for country i; is the cumulative distribution of a standard normal variable.

Results and interpretation

The results of the first generation unit root test are given in table 1. While assuming the common unit root process across Indian states and/or UT in LLC test we are unable to reject the unit root null both the cases. However, while allowing the ρ_i to vary across states and/or UTs in IPS and MW and Choi test we are getting the same results. So while assuming the cross sectional independence in the panel of Indian states/UTs all the five test provides the same results that the Indian PSDP is a unit root process.

Table 1 Results of First generation panel unit root tests assuming cross sectional independence

Method	Statistic	probability
Null: Unit root (assumes common unit root process)		
Levin, Lin & Chu(LLC test)	3.33652	0.9996
Null: Unit root (assumes individual unit root process)		
Im, Pesaran and Shin W-stat(IPS test)	1.12902	0.8706
ADF - Fisher Chi-square (MW test)	37.8635	0.9813
PP - Fisher Chi-square(Choi test)	40.6711	0.9592

Note:***,** and * indicates significance at 1%, 5% and 10% respectively

The assumption of cross sectional independence between Indian states/ UTs in first generational unit root test is unrealistic. Since we are using data within different Indian state there is high possibility that one state's growth rate may affect the growth of other states.

Therefore we relaxed the assumption of cross sectional independence employing the second generation panel unit root test. As mentioned earlier we used two versions of MP tests, Pesaran test and three versions of Choi test to check the robustness of our results. The first and second MP tests provides evidences against the null of unit root, while by using Pesaran test and Choi tests we are unable to reject the unit root null. Among these, MP test is based on residual factor models and suggest estimating the factor loadings by the principal component method. They derived asymptotic properties of the null and alternative hypothesis assuming that N/T→0, as N and T → and there is no deterministic trend. These assumptions are unrealistic in our panel since we have N=31 and T=17 and we are using GDP data where deterministic trend is present. This makes these tests less powerful in our context. Pesaran (2007) shows that the cross-sectional augmented Dicky Fuller test have better power even in case of small T. So with our sample where T<N, we prefer the results provided by Pesaran(2007) test and Choi test. These tests provide evidences of the presence of unit root in panels indicating no tendency of the PSDP variable to move towards mean.

Table 2 Results of First generation panel unit root tests assuming cross sectional independence

Type of Tests	Test statistic
First Moon Perron's test computed in Eq. (8)	-12.0847***
Second Moon Perron's test computed in Eq. (9)	-13.9213***
Pesaran's CIPS test (2007) computed in Eq. (11)	1.0e+007
First Choi's test statistic computed in Eq. (12)	-3.4136
Second Choi's test statistic computed in Eq. (13)	5.0862
Third Choi's test statistic computed in Eq. (14)	5.2777

Note: ***,** and * represents significance at 1%,5% and 10% respectively.

Conclusion

Since Nelson and Plosser (1982) many studies have been conducted to examine the mean reversion properties of macroeconomic variables. Many authors have studied this issue in Asian panels where Indian data were also examined. However no study has been done to examine the mean reversion properties of Indian state level data till now. In this study we examined the mean reversion properties of state level PSDP of India for the period 1993-94 to 2009-10 in panels. We have done this analysis using first generation and second generation panel unit roots, where first generation tests assumes cross section independence and second generation tests relaxes this assumption. The first generation test performed are LLC test, IPS test, MW test and Choi test, where as we employed MP test, Pesaran test and Choi test assuming cross sectional dependence. The entire first generation test provides evidences for presence of unit root in Indian date. But since cross sectional dependence is possible across Indian state PSDP we concentrate on the second generation test. Pesaran (2007) tests and Choi tests results provide no evidence of mean reversion in Indian state level PSDP. These tests are more suitable for our panel with T<N and we concludes that the Indian percapita SDP data contains a unit root, where there is no tendency to return to the long term mean.

These results provide evidences for real business cycle theory, where the shocks on the output variable have permanent effect. The output data shows no tendency to return to its natural rate. This necessitates the stabilisation policies in the economy to control the fluctuations.

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