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Structural Breaks and Unit Roots in Indian Macroeconomic Variables

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Abstract. *This study intends to examine the presence of structural breaks in Indian GDP, GNP and its various components. We have used recently developed unit root test suggested by Narayan and Popp (2010), which can identify two structural breaks. It is found that the extensive reforms in the 1990's affected the growth of GDP, GNP and sectors such as trade, Finance and public administration while agriculture and manufacturing sectors are unaffected. The 1980's initial reforms have impact on GDP, GNP, Finance and public administration. It is found that post 1990 reforms implemented in India failed to have an effect on agriculture and manufacturing. This necessitates further reforms in agriculture and manufacturing sector to accelerate the growth in these sectors. This is the first study to use the Narayan and Popp (2010) unit root test with two structural breaks to check the stationarity of the economic times series and identify the breaks in Indian context.*

Keywords: Economic reforms, economic time series, Structural breaks, unit roots.

JEL Classification: B22, L16.

It is a well established argument that the economic reforms helped the Indian economy to recover from the “Hindu growth rate” of the first three decades of independence. But whether the economic reforms implemented in 1991 or the so called limited economic reforms of 1980’s, have helped the Indian economy to break the Hindu growth vicious circle is an empirical question addressed by many authors (Panagaria, 2003; Wallack, 2003 and De Long 2004). The question can be answered by identifying the structural breaks in the macroeconomic data. The timing of structural changes are important for policy analysis since it provides information about the effect of economic crises, changes in institutional arrangements, policy changes and regime shifts. Wallack (2003) has used F test to identify the structural breaks in Indian economy and provided evidences for increase in GDP growth rate in early 1980’s due to the reforms. But she provides little evidence for these reforms affected the sectoral growth rates of agriculture, manufacturing and services. She found that extensive reforms in 1991 did affect the growth of trade, transport, storage and communication sectors and it was too early to examine the effect of these reforms on other sectors of the economy since they used data till 2002.

In this study we are addressing the same issues addressed by Wallack “What have been critical turning points for the Indian macro-economy over the past five decades? When did the country's growth rate accelerate from the so-called 'Hindu rate' of 3 per cent annually? And when, if at all, has the growth rate of various sectors of GDP accelerated?” Further we examine the unit root properties of Indian macroeconomic variables while identifying the structural breaks in the data employing the recent developments of time series literature. We identify the unit root properties and structural breaks in Indian GDP, GNP and its various components.

Considering structural breaks in unit root test

Perron (1989) showed that the exclusion of structural breaks while modelling the unit root often leads to accepting the false null hypothesis. Since Perron many authors have addressed this issue by identifying the breaks endogenously and exogenously. Prominent endogenously incorporating breaks test include Zivot and Andrews (1992), Lumsdaine and Papell (1997), Lee and Strazicich (2003 and 2004). Zivot and Andrews (1992) use dummy variable for each possible break data and the break dates are identified based on the minimum t-statistic (i.e. most negative). Following Zivot and Andrews (1992), Lumsdaine and Papell (1997) developed a test incorporating two structural breaks. Lee and Strazicich (2003, 2004) showed that the ADF type tests given by Zivot and Andrews (1992) and Lumsdaine and Papell (1997) examine the existence of a break-point for a period prior to the true break-point (i.e., TBt-1 rather than TBt). Hence, both the tests have a bias in estimating the true parameter, which causes a spurious result. This limitation was later trounced by Lee and Strazicich (2003) who proposed the LM based unit root test having two structural breaks. In their subsequent paper in 2004, they proposed a minimum Lagrange Multiplier (LM) unit root test with one break. However, Popp (2008) observed that spurious regression arises from different interpretations of test parameter under the null and alternative hypothesis, since the parameters influences the selection of the break date. Narayan and Popp (2010) (hereafter NP test) solved this problem (following Schmidt and Phillips, 1992) by developing an ADF type test for the case of innovational outlier (IO), where the Data Generating Process is formulated as an unobserved component model. NP (2010) claims that in the new test "critical values (CVs) of the test, assuming unknown break dates, converge with increasing sample size to the CVs when break points are known". Therefore, it identifies the break point more accurately than the earlier tests. Further breaks in trend and levels are allowed in both null and alternative hypotheses (M1 allows breaks in level and M2 allows breaks in both level and trend). Hence in this study we are employing the NP test to identify the structural breaks and examining the unit root properties simultaneously.

Methodology

Narayan and Popp (2010) have defined the test as follows. Suppose, we consider an unobserved components model to represent the DGP (Data Generation Process) and the DGP of the time series yt has two components, a deterministic component (dt) and a stochastic component (ut), as follows:

$$y_t = d_t + u_t, \tag{1}$$

$$u_t = \rho u_{t-1} + \varepsilon_t, \tag{2}$$

$$\varepsilon_t = \Psi^*(L)e_t = A^*(L)^{-1}B(L)e_t, \tag{3}$$

et is a white noise process, such that $e_t \sim NIID(0,\sigma^2)$. By assuming that the roots of the lag polynomials A*(L) and B(L), which are of order p and q, respectively, lie outside the unit circle, NP (2010) considered two different specifications for trending data- one allows for two breaks in level (denoted as model 1 i.e., M1) and the other allows for two breaks in level as well as slope (denoted as model 2 i.e., M2). The specification of both models differs in terms of the definition of the deterministic component, dt:

$$d_t^{M1} = \alpha + \beta t + \Psi^*(L)(\theta_1 DU'_{1,t} + \theta_2 DU'_{2,t}), \tag{4}$$

$$d_t^{M2} = \alpha + \beta t + \Psi^*(L)(\theta_1 DU'_{1,t} + \theta_2 DU'_{2,t} + \gamma_1 DT'_{1,t} + \gamma_2 DT'_{2,t}), \tag{5}$$

With $DU'_{i,t} = 1(t > T'_{B,i}), DT'_{i,t} = 1(t > T'_{B,i})(t - DT'_{B,i}), i = 1,2.$ (6)

Where, $T'_{B,i}$, i = 1, 2, denote the true break dates, θi and γi, indicate the magnitude of the level and slope breaks, respectively. The inclusion of $\Psi^*(L)$ in Equations (3) enables the breaks to occur slowly over time i.e., it assumes that the series responds to shocks to the trend function the way it reacts to shocks to the innovation process et (Vogelsang and Perron, 1998). This process is known as the IO model and the IO-type test regressions to test for the unit root hypothesis for M1 and M2 can be derived by merging the structural model **(1)–(5).** The test regressions can be derived from the corresponding structural model in reduced form as follows:

$$y_t^{M1} = \rho y_{t-1} + \alpha_1 + \beta^* t + \theta_1 D(T'_B)_{1,t} + \theta_2 D(T'_B)_{2,t} + \delta_1 DU'_{1,t-1} + \\ + \delta_2 DU'_{2,t-1} + \sum_{j=1}^{k} \beta_j \Delta y_{t-j} + e_t, \tag{7}$$

With $\alpha_1 = \Psi*(1)^{-1}[(1-\rho)\alpha + \rho\beta] + \Psi*'(1)^{-1}(1-\rho)\beta, \Psi*'(1)^{-1}$ being the mean lag, $\beta^* = \Psi*(1)^{-1}(1-\rho)\beta, \phi = \rho - 1, \delta_i = -\phi\theta_i and D(T_B^{'})_{i,t} = 1(t = T_{B,i}^{'} + 1), i = 1,2.$

$$y_t^{M2} = \rho y_{t-1} + \alpha* + \beta* t + \kappa_1 D(T_B^{'})_{1,t} + \kappa_2 D(T_B^{'})_{2,t} + \delta_1^* DU_{1,t-1}^{'} +$$

$$+ \delta_2^* DU_{2,t-1}^{'} + \gamma_1^* DT_{1,t-1}^{'} + \gamma_2^* DT_{2,t-1}^{'} + \sum_{j=1}^{k} \beta_j \Delta y_{t-j} + e_t, \quad (8)$$

Where, equation (13) and (14) are IO-type test regression for M1 and M2 respectively, $\kappa_i = (\theta_i + \gamma_i), \delta_i^* = (\gamma_i - \phi\theta_i), and\ \gamma_i^* = -\phi\gamma_i, i = 1,2.$

In order to test the unit root null hypothesis of $\rho = 1$ against the alternative hypothesis of $\rho < 1$, we use the t -statistics of $\hat{\rho}$, denoted $t_{\hat{\rho}}$, in equations (7) and (8).

Since it is assumed that true break dates are unknown, $T_{B,i}^{'}$ in equations (9) and (10) has to be substituted by their estimates $\hat{T}_{B,i}$, i = 1, 2, in order to conduct the unit root test. The break dates can be selected simultaneously following a grid search procedure or a sequential procedure comparable to Kapetanios, (2005). Narayan and Poop, (2010) have preferred sequential procedure as because it is far less computationally demanding therefore; we have also followed sequential procedure.

The first step in this case is the search for a single break according to the maximum absolute t-value of the break dummy coefficient θ_1 for M1 and κ_1 for M2. Thereafter, we impose the restriction $\theta_2 = \delta_2 = 0$ for M1 and $\kappa_2 = \delta = \gamma = 0$ for M2 and hence, we have:

$$T_{B,1}^{'} = \begin{cases} \arg\max_{T_{B,1}} \left| t_{\hat{\theta}_1}(T_{B,1}) \right|, for\ M1, \\ \arg\max_{T_{B,1}} \left| t_{\hat{\kappa}_1}(T_{B,1}) \right|, for\ M2 \end{cases} \quad (9)$$

So, in the first step, the test procedure reduces to the case described in (Popp, 2008). Imposing the first break $\hat{T}_{B,1}$ in the test regression, we estimate the second break date $\hat{T}_{B,2}$. Again we maximize the absolute t-value; this time θ2 for M1 and κ2 for M2. Hence, we have:

$$T_{B,1}^{'} = \begin{cases} \arg\max_{T_{B,2}} \left| t_{\hat{\theta}_2}(\hat{T}_{B,1}, T_{B,2}) \right|, for\ M1, \\ \arg\max_{T_{B,2}} \left| t_{\hat{\kappa}_2}(\hat{T}_{B,1}, T_{B,2} \right|, for\ M2 \end{cases} \quad (10)$$

Estimated results and discussion

We used two models (M1 and M2) of NP test; M1 assuming both the breaks in intercept only and; M2 assuming break in both intercepts and trend. Among the seven series studied agriculture and public **administration series are found** to be stationary since the unit root null is rejected in both the cases. Other series poses a unit root, implying that the shocks to the system have permanent effect, since the variables are not returning to the natural path.

In both GDP and GNP series we found intercept breaks in 1989-1990 and 1996-97. But in model 2 we identified first break in 1985-86 for both the series and 1988-89 for GDP and 1990-91 for GNP series. These breaks are consistent with the policy changes. The break in 1985-86 indicates that the reforms in early 1980's did affect the growth of GDP and GNP series in the mid 1980's. This is again supplemented by the remittance from abroad in the late 1980's (as Wallack 2003 explained). The breaks in 1996-97 provide apparent evidence for the effect of extensive reforms in 1990s on the economic growth, in that year India achieved more than 8% growth first time after the 1991 reforms. Similarly in 1988-89 also India achieved high growth rate just before the severe crisis in 1990-91. Therefore, GNP and GDP data show that the reforms in early 1980's did affect the growth in late 1980's and similarly the 1991 reforms affected the growth in the second half of the decade.

The sectoral breaks estimation provides a different picture about the Indian economy. This is because the agriculture sector experienced intercept and trend breaks in 1965-66 and 1978-79. The first break is coincided with the increase in cultivable land as part of green revolution and the 1978-79 breaks is corresponding to the increase in food grain production as a result of the green revolution. The manufacturing sector experienced breaks in late 1970's and late 1960's. The 1976-77(in model 2) and 1978-79 (model 1) breaks are consistent with the partial liberalisation measures introduced in 1976. In that year government allowed the imports of capital goods under OFL scheme. The 1973-74 breaks can be considered to be related to the nationalisation of Banks in 1969 and 1966-67. Breaks can be considered to be related to the growth of the core sector such as agriculture. But interestingly the manufacturing sector didn't experience any break in the post 1990 period.

Table 1

	M1				M2			
Variable	TB1	TB2	Test statistic	lag	TB1	TB2	Test statist	lag
GDP	1988-89	1996-97	-3.70	0	1985-86	1988-89	-3.69	2
GNP	1989-90	1996-97	-3.72	0	1985-86	1990-91	-3.58	2
Agriculture	1965-66	1978-79	-0.93	5	1965-66	1978-79	-6.98*	0
manufacturing	1966-67	1978-79	-3.37	2	1973-74	1976-77	-3.55	2
Trade	1978-79	1994-95	1.11	0.	1978-79	1994-95	-3.35	4
Finance	1973-74	1993-94	0.71	0	1975-76	1980-81	-2.56	2
Public Admin.	1988-89	1998-99	-3.97	4	1976-77	1997-98	-4.05***	0

*,**,*** indicates significance at 1%,5%,10% respectively. Null Hypotheses: the variable contains a unit root

The breaks in trade and finance sectors also coincided with the economic events in the Indian economy. For example trade, transport and communication sector experienced breaks in 1978-79 and 1994-95. The first break is consistent with the partial liberalisation in the import of capital goods, supported by the favourable foreign exchange reserve as a result of the increased remittance from Middle East. The second break shows the effect of extensive liberalisation in early 1990's. We found first break in Finance sector data in the year 1973-74 (effect of nationalisation of banks in 1969) and the second break occurred in the year 1994-95 as a result of the financial sector reforms in 1990's. The break in public administration in 1998-99 can be considered as part of the second generation reforms focusing on social sector and the Kargil war.

Conclusion

We examined the stationarity properties and structural breaks in India's GNP, GDP and its sectoral components by using the recent developments in time series econometrics. We found clear evidence on the effect of initial liberalisation and extensive liberalisation on India's GDP, GNP and sectors such as trade, Finance and public administration. It is found that the initial reforms started in late 1970's affected the growth of sectors such as Trade, agriculture and manufacturing but the effect on GDP and GNP is visible only in the late 1980's. The post 1990 reforms did affect the GDP, GNP and sectors such as trade, finance and public administration. But it failed to have an effect on agriculture and manufacturing. This necessitates further reforms in agriculture and manufacturing sector to accelerate the growth in these sectors.

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