Structural Breaks and Unit Roots: A Further Test of the Sustainability of the Indian Fiscal Deficit*

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Abstract

If public expenditure and public revenue are $I(0)$ public debt is sustainable but if these are $I(1)$ and not cointegrated or have a cointegrating vector different from [1, -1] the public debt is said to be unsustainable. Extant work indicates that India's public debt is unsustainable. We re-investigate this issue by allowing for endogenous structural breaks for two data sets - the British period 1871-1921 and the post independence period 1950-1997. Revenue and expenditure series (nominal as well as real) are trend stationary with structural breaks, at least for the post independence period. Thus Indian public debt is not unsustainable.

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1 Introduction

Rapid accumulation of domestic debt can lead to severe macroeconomic problems, and can impede control of the fiscal deficit itself. This is particularly relevant for developing countries where the need for public expenditure is high and where tax systems and public regulation and accountability are weak. To take only one example, Zimbabwe's fiscal deficit was estimated to be close to 20 percent of GDP in 2000."Public debt is rising rapidly, with new debt being issued to meet interest payments (the so-called 'Ponzi' game). Interest payments on domestic public debt are expected to exceed 50 percent of total government revenues by end-2000, thereby squeezing development and social spending." (EIU 2000). In the case of India, a number of commentators have expressed concern over the government's deficit and mounting debt. Solvency conditions appear to be violated in the Indian case (Buiter & Patel 1992),(Buiter & Patel 1995),(Jha 1999) and there is a fear that, with existing trends, the public sector may become bankrupt in finite time. The present paper revisits this issue. It argues that recent advances in the theory of testing for unit roots - in particular, the literature associated with endogenous structural breaks - indicate that the pubic debt in India is indeed sustainable. The plan of this paper is as follows. Section two develops the intertemporal government budget constraint and section three details the data used in this paper. Section four works with the one structural break of Zivot & Andrews (1992) whereas section five examines the two structural breaks case. Given that our data set is not very long, we are unable to proceed to the case of three or more structural breaks. However, we are able to establish that both series are I(0) with one or two structural breaks. Hence, in sharp distinction with the extant literature, we discover that the Indian public debt situation is not unsustainable. Section six concludes the paper.

2 Sustainability of the Domestic Fiscal Debt

The Government Intertemporal Budget Constraint

In this section we develop the simple analytics of sustainability for the domestic deficit. The most straightforward way to assess the sustainability of a public debt situation is to start from the governmental intertemporal budget constraint. This is written in nominal terms as:

$$G_t - T_t + r_t B_{t-1} = B_t - B_{t-1} \tag{1}$$

Where G_t is the value of government expenditures (purchases of goods and services plus transfer payments); B_t is the government debt at the end of period t, T_t is the government's tax revenue and r_t is the one-period rate of interest payable on the government debt. (1) states that in the absence of money finance, the government budget deficit must be financed by new debt creation. Hence, expressing (1) in terms of ratios to gross GDP we will have:

$$b_t = (1 + r_t)(1 + \pi_t + \eta_t)^{-1} b_{t-1} + (g_t - \tau_t) \tag{2}$$

Where the lower case letters denote the ratio of the corresponding uppercase variables to nominal GDP: $b_t = B_t/P_tY_t$; $g_t = G_t/P_tY_t$; $\tau_t = T_t/P_tY_t$; with P and Y being the price level and real GDP respectively. $\pi_t = (P_t - P_{t-1})/P_{t-1}$ is the rate of inflation and $\eta_t = (Y_t - Y_{t-1})/Y_{t-1}$ is the rate of growth of real GDP. In the derivation of 2 we have used the relation that

$P_tY_t = (1 + \pi_t)(1 + \eta_t)P_{t-1}Y_{t-1} \approx (1 + \pi_t + \eta_t)P_{t-1}Y_{t-1}$

$(g_t - \tau_t)$ is the primary deficit expressed as a percentage of GDP. We have the following cases:

Case 1: $r_t - \pi_t < \eta_t$

In this case in (2) the debt ratio will stabilize and the economy will remain solvent if: $\lim_{t\to\infty} E(b_t) = 0$

If the initial debt to GDP ratio (b_0) is strictly positive, this requires two conditions: $r_t - \pi_t < \eta_t$ for all t so that the debt ratio stabilizes rather than explodes. This is the so- called sustainability condition and makes any stable path of the primary deficit consistent with a stable public debt to GDP ratio. In addition we have condition (b) that $g_t - \tau_t \leq 0$ on average, if not in every period, so that the debt burden is ultimately liquidated.

These two conditions are necessary and sufficient and ensure that the debt, no matter how large, can be paid off through tax increases or expenditure cuts or inflation. Thus the government is solvent. The steady state (finite) value of the debt-GDP ratio is:

$$\bar{b} = b_t = b_{t-1} = (1 + \eta + \pi)(\eta - (r - \pi))^{-1}(g - \tau) \; if \; r - \pi < \eta \tag{3}$$

(3) emphasizes a strong link between the government's indebtedness and its primary deficit.

Case2: $r_t - \pi_t > \eta_t$

In this case the debt is unsustainable and the debt stock will become infinite no matter what sequence of primary deficits are chosen unless the debt stock itself can be offset by matching the sequence of increasing but discounted primary surplus in the future. To consider sustainability further here transform (2) to get:

$$b_t = (1 + \theta_t)b_{t-1} + (g_t - \tau_t) \tag{4}$$

where we have used the fact that:

$(1 + r_t)(1 + \pi_t + \eta_t)^{-1} = 1 + r_t - \pi_t - \eta_t$

$\theta_t = r_t - \pi_t - \eta_t$ is the real interest rate minus the rate of growth of real GDP. (4) will always hold *ex post*. Looking forward we can write the identity in (4) for time period $t + 1$ as:

$$b_t = E_t[(1 + \theta_t)^{-1} b_{t+1} - (g_{t+1} - \tau_{t+1})] \tag{5}$$

where b_t is known in period t. For this one period constraint to hold in expectational terms, this must equal the expected discounted net debt-to-GDP ratio in period $t + 1$ conditional on information at time t. For fiscal policy to be sustainable for one time period (5) must hold. Writing the budget constraint of (5) for subsequent time periods $t+2$, $t+3$ etc. and solving forward we get:

$$b_t = E_t \sum_{s=0}^{\infty} \prod_{i=1}^{s} (1+\theta_{t+i})^{-1} (\tau_{t+s} - g_{t+s}) + E_t \prod_{i=1}^{s} (1+\theta_{t+i})^{-1} b_{t+s} \tag{6}$$

It is apparent that

$\prod_{i=1}^{s}(1+\theta_{t+i})^{-1}$ is a time-varying real discount factor adjusted for the growth of real GDP with $\theta > 0$. A necessary and sufficient condition for sustainability is that as $s \to \infty$ the discounted value of the expected debt-to-GDP ratio converges to zero. This is a transversality condition and can be expressed as:

$$\lim_{s\to\infty} E_t \prod_{i=1}^{s} (1+\theta_{t+i})^{-1} b_{t+s} = 0 \tag{7}$$

(7) implies that a government is solvent if the transversality condition guarantees the non-explosiveness of the public debt and when no Ponzi games are allowed, i.e., no new debt is issued by the government to meet interest payments. Hence it follows that the current debt is offset by the sum of the current and expected future discounted surpluses, implying that the budget constraint holds in present value terms with:

$$b_t = \lim_{s\to\infty} E_t \sum_{s=0}^{\infty} \prod_{i=1}^{s} (1+\theta_{t+i})^{-1} (\tau_{t+s} - g_{t+s}) \tag{8}$$

The Critical Value of Debt-GDP Ratio

Given 8 and using $z_m = \tau_{max} - g_{min}$ as a definition of the maximum level of the government's primary surplus we can determine the critical value of the public debt ratio (b^C), which will satisfy the sustainability condition:

$$b_t \leq b^C = z_m (r - \pi - \eta)^{-1} \tag{9}$$

We can also determine the necessary primary surplus, given the initial debt ratio, b_0, the real interest rate and the growth rate of real GDP, to stabilize the future debt to GDP ratio. when $r - \pi > \eta$ we can use (2) to define the finite value (b_0) to which b converges as:

$$z^{**} = (r - \pi - \eta)(1 + \eta + \pi)^{-1} b_0 \tag{10}$$

The gap between the stabilizing primary surplus (z^{**}) and the actual primary surplus ($\tau_t - g_t$) may be used as a sustainability indicator. This indicator gives the magnitude by which either revenue must be increased or expenditure must be cut relative to income to stop the debt ratio from growing.

From the above analysis it is clear that sustainability of the public debt is essentially an intertemporal question. In particular, every temporary deficit can be sustainable so long as it is matched by an adequate future surplus. Most empirical tests on sustainability apply time series methods and ask whether the observed characteristics of debt-related variables satisfy the solvency condition in (7). This solvency condition can be tested in a variety of ways depending on the processes postulated for the primary deficit ($g_t - \tau_t$) and the real interest rate adjusted for output growth (θ_t). Hamilton & Flavin (1986) and Trehan & Walsh (1991), among others, examine the case where ($g_t - \tau_t$) is strictly exogenous and θ_t is constant. Wilcox (1989) considers the case with exogenous ($g_t - \tau_t$) but variable θ_t. Uctum & Wickens (1997) consider the case where θ_t is stochastic and ($g_t - \tau_t$) could be exogenous or endogenous. For the sake of simplicity, we will assume that the real interest rate adjusted for output growth, θ_t, is constant with an unconditional mean. To proceed further now take the first difference of (6), substitute for Δb_t using (4) and simplify to get:

$$\Delta b_t = d_t - \tau_t = \sum_{s=0}^{\infty} (1+\theta)^{-s-1} E_t(\Delta\tau_{t+s} - \Delta d_{t+s}) + \lim_{s\to\infty} (1+\theta)^{-s-1} E_t b_{t+s} - \lim_{s\to\infty} (1+\theta)^{-s-1} E_{t-1} b_{t+s-1} \tag{11}$$

where $\Delta b_t = g_t + \theta b_{t-1} - \tau_t = d_t - \tau_t$ with $d_t = g_t + \theta b_{t-1}$

is defined as total government expenditure inclusive of expenditure on goods and services, transfer payments and interest on the debt. If the government satisfies its intertemporal budget constraint then the expected limit term in (11) is zero so that the sum of the current budget surplus $(\tau_t - d_t)$ and the expected present discounted value of future surplus will equal the amount needed to repay the principal and the interest on the initial debt. When this condition holds, it can be said that the current expected paths of government spending and taxation are sustainable.

As Papadopoulos & Sidiropoulos (1999) demonstrate if the limit terms on the right-hand-side of (11) are zero, then a certain cointegrating relationship emerges. Hence cointegration is a necessary condition for the intertemporal budget constraint to hold. To see this assume that d_{t+s} and τ_{t+s} follow random walks with drift, i.e., these variables follow the following time series processes:

$$\Delta d_t = \alpha_d + \nu_{d,t+s} \tag{12}$$

$$\Delta \tau_t = \alpha_\tau + \nu_{\tau,t+s} \tag{13}$$

where α_d and α_τ are constants and ν_d and ν_τ are zero-mean stationary processes. Hence (11) can be rewritten as:

$$d_t - \tau_t = \alpha + \lim_{s\to\infty}(1+\theta)^{-s-1}E_t b_{t+s} - \lim_{s\to\infty}(1+\theta)^{-s-1}E_{t-1}b_{t+s-1} + \nu_t \tag{14}$$

with

$\alpha = \sum_{s=0}^{\infty}(1+\theta)^{-s-1}(\alpha_d - \alpha_\tau)$

$\nu_t = \sum_{s=0}^{\infty}(1+\theta)^{-s-1}(\nu_{d,t+s} - \nu_{\tau,t+s})$

Given that d_t and τ_t are $I(1)$ and given that (12) and (13) imply stationarity on the right hand side of (11), the left hand side of (11) must also be stationary for which a necessary condition is that (14) be stationary, which will be the case when d_t and τ_t are cointegrated. Thus a test for sustainability of the debt would check for the cointegration of these two variables if they are $I(1)$. This cointegrating regression would take the form:

$$\tau_t = \alpha + \beta d_t + \nu_t \tag{15}$$

Formally, then, if d_t and τ_t are $I(1)$, the null hypothesis is that d_t and τ_t are cointegrated and that $\beta = 1$. If this null hypothesis is not rejected then the public debt is sustainable.

Thus understanding the unit root properties of the revenue and expenditure series would be crucial to establishing the sustainability or otherwise of the public debt. This paper is focused on this issue. In particular, we are interested in the possibility that the data might actually be I(0) with one or more structural breaks whereas standard unit root tests could be rejecting the null of unit roots .

A structural break is said to have taken place when a change is observed in the regression parameters of the model. Several studies have reported instances where a series which was classified as non-stationary (i.e., $I(1)$) in the absence of structural break hypothesis was actually trend stationary (i.e.,$I(0)$) once structural break was accounted for in the analysis. Thus the conventional unit root tests erroneously fail to reject the null of unit root for the series. Structural breaks are a result of some event significantly affecting the variables being studied. Such breaks can lead to a permanent shift in the level or slope (or both) of the series but the basic nature of the series remains unchanged. With such events or shocks accounted for, the series can be trend stationary but with a structural break. More recent literature admits the possibility of more than one such structural break. The purpose of this paper is to ascertain whether the public debt of the central government in India is sustainable. Extant studies ((Buiter 1985),(Buiter & Patel 1992) (Jha 1999) that have not admitted the possibility of structural breaks have come to the conclusion that the Indian public debt is non sustainable since both revenue as well as expenditure series are $I(1)$ and either there is no cointegration between the two variables or the cointegrating vector does not have the value [1,-1].

3 Data

The economic history of public revenues and expenditures in India has witnessed several changes over the past 125 years or so. Until 1871 the fiscal regime was one of complete centralisation. The revolt of 1857 had forced the government of India to tighten its control over the state (provincial) governments and provincial governments were totally dependent on the funds allocated by the central government. This led to the development of distortions such as inequality among states as well as the inefficiency associated with a centralized fiscal system. State governments were given finances on the basis of their demand and such allocations bore little relation with the revenue that was obtained from them. The central government alone was responsible for the collection of revenues. In response to the needs for establishing British authority, the central government had to make large expenses whereas the revenues were stagnant principally because of stagnant economic conditions. As a result, the central government ran huge deficits, which soon became unsustainable. In 1871 Lord Mayo replaced the centralized arrangements with a system of provincial settlements, thus beginning an era of decentralization for the Indian economy. Under this new system both the central and provincial governments shared some of the heads of the revenue while others were reserved only for either the central government or the provincial governments. The allocation rule was to be revised every five years.

This provision for periodic revisions turned out to be a major defect of the decentralization policy and had to be removed in 1904 when the settlements were made quasi-permanent. The Government of India Act was passed in 1919 and came into force in 1921. In this period a few more states were formed, leading to a geared up decentralization process.

We wish to compare fiscal sustainability for the British and the post-independence periods and analyze the revenue and expenditure of the Central Government of India for these two major periods. We use annual data on Central Government revenue and expenditure at current prices for the period 1872 to 1997. This period is split up into two sub periods 1872-1921, the British Period, (henceforth BP) and 1950-1997, the post independence period, (henceforth PI). BP stops at 1921 since the period after 1921 was characterized by considerable reorganization of states. For PI the data for public revenue and expenditure are available on a consistent basis until 1997. After that there were several important changes in definitions. The data source is the Reserve Bank of India database and various budget documents. Data for PI are also available in real terms, which is an advantage in that it is possible to test whether inflation had any role in determining the nature of the series and the dates of the structural breaks. Independence provides a natural break in the data set chosen. With independence the structure of administration went through considerable change, and even the geographical size of the country altered radically. Hence, it does not seem appropriate to study the British and post independence periods together[1].

4 Fiscal Sustainability with one structural break

Nelson & Plosser (1982) initiated the contemporary debate on structural breaks. For some macro variables of the US economy they attempted to fit appropriate time series models and concluded that most of these series were non-stationary with no tendency of returning to a deterministic path. They opined that shocks have a permanent effect on the long run level of the macroeconomic series. This challenged the then prevailing view that shocks subside after a period of time and, in the long run, any series returns to its trend path. Perron (1989) admitted the possibility of (exogenous) structural breaks in the Nelson and Plosser data series and opined that the conventional unit root test could fail to reject the unit root hypothesis of non-stationarity even for series known to be trend stationary with structural break. He proposed a modified version of the conventional ADF test to rectify

[1]For a good review of fiscal conditions prior to independence see (*Banking and Monetary Statistics of India* 1954)

this.

Zivot & Andrews (1992)criticized Perron's assumption of an exogenous date of structural break and permitted the date of the structural break to be endogenously determined within the model. This reversed some of the results of Perron: They failed to reject the unit root null for four of the series which Perron had classified as stationary. The basic specification of the Zivots and Andrews model for any time series G_t is:

$$\Delta G_t = \alpha + \beta t + \gamma DI1_t + \omega DS1_t + \mu G_{t-1} + \sum_{i=1}^{k} c_i \Delta G_{t-i} + \epsilon_t \tag{16}$$

for $t = 1, , T$; where $c(L)$ is a lag polynomial of known order k and $1-c(L)L$ has all its roots outside the unit circle. $DI1_t$ is the indicator dummy variable for a mean shift occurring at time $SB1$ and $DS1_t$ is the corresponding trend shift variable such that $DI1_t = 1$ for $t > SB1$. $DS1_t = (t - SB1)$ if $(t < SB1)$. The k extra regressors are taken to address the problem of autocorrelation, i.e., the temporal dependence in the error terms. A test of the unit root hypothesis has the null $\mu = 0$. The alternative hypothesis is that the series is $I(0)$ with one structural break. Restricted version of (16) discussed by Zivot and Andrews include:

$$\Delta G_t = \alpha + \beta t + \gamma DI1_t + \mu G_{t-1} + \sum_{i=1}^{k} c_i \Delta G_{t-i} + \epsilon_t \tag{17}$$

This model allows for a one-time change in levels at $SB1$.

$$\Delta G_t = \alpha + \beta t + \omega DS1_t + \mu G_{t-1} + \sum_{i=1}^{k} c_i \Delta G_{t-i} + \epsilon_t \tag{18}$$

This model permits a one-time change in the slope at SB1.

In these specifications, the choice of the lag length, k, is crucial. Hall (1994) suggests that for moderate to large samples a general-to-specific approach performs better than standard information criteria such as those due to Hannan, Quinn and Akaike and Schwarz. We, therefore, use the general to specific approach adopted by Perron (1989). In accordance with this we begin with a large value of $k(= 8)$ and keep reducing this until the t-value (calculated from ADF test) on $\mu(k)$ is greater than 1.6 in absolute value and that of $\mu(l)$ is less than 1.6 for $l > k$. Table 1 summarizes the lag value k for BP and PI.

—Insert Table1 about here—

The date of the structural break ($SB1$) is allowed to vary between $t = 2$, to $T-1$ where T is the sample size. Thus this technique does not permit structural breaks at the beginning and the end of the period. We assign a dummy variable for each value of $t \in [2, T-1]$. Hence we get $T-2$ combinations of the data set. The Zivot and Andrews procedure for deciding the date of the structural break chooses that period as the break point which supports the alternative hypothesis the most, i.e., supports the null hypothesis the least. To do this we run a sequential OLS procedure and test for the significance of the coefficient of G_{t-1} (i.e., whether $\mu = 0$). We thus get $T-2$ t-statistics along with the corresponding coefficients. To decide on $SB1$, the date of the structural break, we choose the minimum value of one sided (left tailed) t statistic calculated. The date corresponding to this minimum t-statistic is chosen as the date of the structural break. Thus $t(SB1) = min_{T_i} t_\mu(T_i)$.

It is important to note that the asymptotic distribution of the t-statistic computed here is not the standard t-distribution. Observation specific finite sample critical values have to be generated using Monte Carlo simulations with the exact number of observations for models (16), (17) and (18). We generated these data under the null hypothesis of the unit root, i.e., $\Delta G_t = \epsilon_t$. Each simulation took the data set corresponding to the estimated break date and performed an OLS estimation to find the t-statistic corresponding to μ. Each such Monte Carlo simulation was performed 500 times and the experiment itself was replicated 1000 times. An examination of the density functions of the critical values after admitting one structural break are plotted in Figure 1 and show that this distribution is not normal. This justifies the methodology used here.

—Insert Figure1 about here—

As Table 2 indicates (with Table 3 showing the corresponding critical values), for PI real revenue and expenditure series are $I(0)$ with one structural break. In Table 4 we report corresponding results for BP with the critical values reported in Table 5.

—Insert Table1,2,3,4,5 about here—

For this period, the expenditure series is $I(0)$ with one structural break. Thus it appears that real expenditure, real revenue and nominal expenditure series for PI are stationary. Each series has an endogenous break. Nominal revenue for PI is I(1). For BP all revenue and expenditure series are I(1).

5 Fiscal Sustainability with two structural breaks

The results in Tables 2 and 4 are, in themselves, a departure from accepted wisdom. However, as Lumsdaine & Papell (1997) suggest, a series for which the unit root hypothesis cannot be rejected using a procedure that admits one structural break may actually be $I(0)$ if more than one structural break is permitted. We now pursue this possibility.

The technique used by Lumsdaine & Papell (1997) builds upon the sequential procedure suggested by Banerjee, Lumsdaine & Stock (1992). The general model consisting of two structural breaks is written as:

$$\Delta G_t = \alpha + \beta t + \gamma DI1_t + \omega DS1_t + \psi DI2_t + \theta DS2_t + \mu G_{t-1} + \sum_{i=1}^{k} c_i \Delta G_{t-i} + \epsilon_t \qquad (19)$$

for $t = 1, , T$ and where $c(L)$ is a lag polynomial of known order k and $1 - c(L)L$ has all its roots lying outside the unit circle. $DI1_t$ and $DI2_t$ are indicator dummies for a mean shift occurring at times $SB1$ and $SB2$, respectively and $DS1_t$ and $DS2_t$ are the corresponding trend shift variables, such that $DI1_t = 1$if $(t > SB1)$;

$DI2_t = 1$ if $(t > SB2)$;

$DS1_t = (t - SB1)$ if $(t < SB1)$;

$DS2_t = (t - SB2)$ if $(t < SB2)$. The test for unit root has the null hypothesis $\mu = 0$ (i.e.

series is $I(1)$) and the alternate hypothesis is that series is $I(0)$ with two structural breaks. (19) is the general form of the Lumsdaine & Papell (1997) specification. Special cases of (19) are:

$$\Delta G_t = \alpha + \beta t + \gamma DI1_t + \psi DI2_t + \mu G_{t-1} + \sum_{i=1}^{k} c_i \Delta G_{t-i} + \epsilon_t \tag{20}$$

and

$$\Delta G_t = \alpha + \beta t + \gamma DI1_t + \omega DS1_t + \psi DI2_t + \mu G_{t-1} + \sum_{i=1}^{k} c_i \Delta G_{t-i} + \epsilon_t \tag{21}$$

(20) allows for two changes in the level of the series at $SB1$ and $SB2$ respectively whereas (21) permits one change in the level as well as the trend at time period $SB1$. It should be noted, however, that the possibility of structural breaks occurring in two successive time periods is ruled out. Furthermore, as in the Zivot and Andrews case structural breaks at the beginning and the end of the period are ruled out. Critical values are computed using the asymptotic distribution theory reported in Zivot & Andrews (1992) and Lumsdaine & Papell (1997). A plot of the critical values in Figure 2 indicates the non-normal nature of the series. *—Insert Figure2 about here—*

Table 6 reports results on real variables for PI with 7 reporting the critical values. Table 8 (and 9) report results for BP and Table 10 (and 11) for nominal magnitudes for PI[2].

—Insert Table 6,7,8,9,10,11 about here—

Summary of Results

Table 12 presents a summary of the results from our analysis. For the one break model real revenue, real expenditure and nominal expenditure series of PI are trend stationary with one endogenous break. On extending the analysis to permit an additional endogenous break, the null hypothesis of a unit root is rejected for the expenditure series in BP and nominal revenue series for PI. Both of these are now trend stationary ($I(0)$) but were

[2]Results for the nominal variables with one structural break are not included to save space but these can be obtained from the authors.

$I(1)$ when only one break was permitted. As Table 12 shows, once structural breaks are permitted the only $I(1)$ variable is "revenue" in BP.

—Insert Table 12 about here—

One of the possible reasons for this result could be the small sample size of the data. If we account for two endogenous breaks instead of one, for a small sample then the removal of these break points from the series might affect the trend stationarity of series adversely hence resulting in rejection of the alternative hypothesis (stationarity). This problem did not arise in the long macroeconomic series studied by Nelson & Plosser (1982), Zivot & Andrews (1992) and Lumsdaine & Papell (1997). The crucial question of selection of model specification (one break against two breaks) remains. For the sake of consistency we could choose those models for which the series turn out to be trend stationary with structural break(s). This would involve choosing the one break model for real revenue, real expenditure and nominal expenditure for PI and the two break model for nominal expenditure series in the BP as well as for the nominal revenue series in PI. Both analyses consider three types of trend stationarity -trend in slope, trend in intercept and trend in both slope and intercept. Our results indicate that more than one type of trend model may be appropriate across the cases we study. Hence the choice of the appropriate model depends on the researcher and, in most cases, a careful perusal of the data can give a hint regarding the nature of the series. However, one point that does emerge clearly from the analysis is that once we admit structural breaks in the Indian case we are not able to concur with the extant results that purport to show that the Indian public debt is non sustainable.

6 Conclusions

This paper has revisited an important policy issue in the Indian context - the sustainability of the public debt. It began by spelling out the result that if public expenditure and revenues are both non-stationary then for the public debt to be sustainable they must be cointegrated with a cointegrating vector of [1,-1]. However, critical to this is the correct determination of the time series properties of the expenditure and revenue series.

Whereas standard ADF tests have revealed the public expenditure and revenue series in India to be $I(1)$, this paper has questioned this result by permitting one or two endogenously determined structural breaks. This analysis is conducted for both the British as well as the post independence period. It turns out that, at least for the post independence period public revenue and expenditure series are actually $I(0)$ with structural breaks. Hence the public debt situation in India is not unsustainable. However, this does not mean, of course, that India's fiscal position is comfortable. With high public debt and current government expenditure more than 80% of total government expenditure and more than a third of current expenditure earmarked for interest on past loans, surely the high fiscal deficit is having serious implications for the economy. Leading to a non-sustainable public debt is not, however, among them.

Table 1: Lag length k

British Period (nominal magnitudes)	
Revenue	2
Expenditure	1
Post Independence Period (nominal magnitudes)	
Revenue	8
Expenditure	8
Post Independence Period (real magnitudes)	
Revenue	8
Expenditure	8

Table 2: Post Independence(Real variables) : One Break

Series	Equation	$SB1$	γ	ω	μ
Revenue	16	1959	-0.021	0.059	0.159
			(-0.50)	(0.00)	(4.2)*
	17	1973	-0.044	-	0.127
			(2.32)	-	(4.29)**
	18	1959	-	0.062	0.151
			-	(-0)	(4.16)**
Expenditure	16	1961	-0.031	-0.004	0.173
			(-0.732)	(-0.168)	(3.83)
	17	1961	-0.027	-	0.170
			(-0.8)	-	(3.9)*
	18	1963	-	0.012	0.184
			-	(1.06)	(4.04)**

t-statistic are in parentheses.

**:significant at 5% level.

*:significant at 10% level.

Table 3: Critical Values : One Break

Series	Equation	1%	2.50%	5%	10%
Revenue	16	-5.09	-4.56	-4.29	-4.01
	17	-4.54	-4.27	-4.08	-3.79
	18	-4.94	-4.45	-4.16	-3.96
Expenditure	16	-4.89	-4.57	-4.31	-3.98
	17	-4.75	-4.57	-4.31	-3.98
	18	-4.82	-4.50	-4.31	-3.95

Table 4: British period(nominal variables) : One Break

Series	Model	$SB1$	γ	ω	μ
Revenue	16	1908	-0.014	-0.001	0.241
			(-0.320)	(-0.092)	(2.130)
	17	1917	0.162	-	-0.090
			(1.609)	(-)	(-0.430)
	18	1911	-	-0.003	0.265
			(-)	(-0.480)	(2.270)
Expenditure	16	1917	0.633	-0.129	-0.377
			(7.410)	(-4.150)	(-2.200)
	17	1917	0.450	-	-0.710
			(5.250)	(-)	(-4.000^*)
	18	1914	-	0.022	-0.113
			(-)	(1.290)	(-0.570)

t-statistic are in parentheses.

∗:significant at 10% level.

Table 5: Critical Values : One Break

Series	Equation	1%	2.50%	5%	10%
Revenue	16	-4.67	-4.31	-4.10	-3.84
	17	-4.40	-4.18	-3.97	-3.75
	18	-4.42	-4.24	-4.05	-3.82
Expenditure	16	-4.64	-4.38	-4.14	-3.85
	17	-4.30	-4.25	-4.03	-3.82
	18	-4.36	-4.28	-4.05	-3.83

Table 6: Post Independence(Real variables) : Two Break

Series	Model	Years	γ	ω	ψ	θ	μ
Revenue	19	1959	0.006	0.007	-0.003	-0.126	0.155
		1994	(0.053)	(0.144)	(-0.032)	(0.000)	(2.040)
	20	1963	0.040	-	-0.037	-	0.208
		1984	(1.960)	(-)	(-0.077)	(-)	(3.040)
	21	1959	-0.008	-0.131	-0.035	-	0.145
		1974	(-0.106)	(0.000)	(-0.887)	(-)	(2.480)
Expenditure	19	1959	0.054	0.001	0.005	0.067	0.154
		1983	(1.590)	(0.389)	(0.091)	(0.000)	(2.850)
	20	1973	-0.055	-	-0.015	-	0.113
		1991	(-2.280)	(-)	(-0.750)	(-)	(3.210)
	21	1990	0.007	-0.005	-0.059	-	0.109
		1973	(0.300)	(-0.940)	(-2.250)	(-)	(2.950)

t-statistic are in parentheses.

Table 7: Critical Values : Two Breaks

Series	Equation	1%	2.50%	5%	10%
Revenue	19	-5.05	-4.58	-4.35	-3.06
	20	-4.78	-4.51	-4.24	-4.00
	21	-5.00	-4.52	-4.33	-4.04
Expenditure	19	-5.19	-4.69	-4.42	-4.48
	20	-4.87	-4.55	-4.31	-4.06
	21	-4.94	-4.59	-4.34	-4.10

Table 8: British : Two Break

Series	Model	Years	γ	ω	ψ	θ	μ
Revenue	19	1900	0.015	-0.001	0.419	-0.150	0.243
		1917	(0.650)	(-0.968)	(6.350)	(-10.340)	(1.670)
	20	1900	0.070	-	0.285	-	-0.330
		1917	(1.640)	(-)	(2.300)	(-)	(-1.320)
	21	1905	0.092	-0.009	0.338	-	-0.330
		1917	(1.810)	(-1.760)	(2.500)	(-)	(-1.300)
Expenditure	19	1905	0.098	-0.007	-703.000	-0.105	-0.560
		1917	(2.040)	(-1.460)	(7.660)	(-3.200)	(2.940)
	20	1903	0.092	-	0.504	-	-0.831
		1917	(2.340)	(-)	(5.940)	(-)	(-4.71^{***})
	21	1905	0.150	-0.012	0.618	-	-0.897
		1917	(3.122)	(-2.240)	(6.350)	(-)	(-5.09^{***})

t-statistic are in parentheses.

$***$:significant at 1% level.

Table 9: Critical Values : Two Breaks

Series	Equation	1%	2.50%	5%	10%
Revenue	19	-4.85	-4.42	-4.16	-3.90
	20	-4.63	-4.31	-4.07	-3.84
	21	-4.65	-4.37	-4.08	-3.85
Expenditure	19	-4.69	-4.43	-4.13	-3.87
	20	-4.55	-4.26	-4.05	-3.83
	21	-4.67	-4.41	-4.07	-3.81

Table 10: Post Independence(Nominal): Two Breaks

Series	Model	Years	γ	ω	ψ	θ	μ
Revenue	19	1971	-0.089	-0.004	-0.023	-0.004	0.139
		1991	(-3.930)	(-1.511)	(-1.585)	(-1.181)	(3.570)
	20	1963	0.002	-	-0.034	-	0.212
		1972	(0.106)	(-)	(-2.050)	(-)	(3.890*)
	21	1967	-0.075	-0.013	-0.029	-	0.133
		1982	(-4.540)	(-2.980)	(-2.110)	(-)	(3.220)
Expenditure	19	1959	0.009	-0.149	-0.044	-0.017	0.261
		1962	(0.090)	(0.000)	(-0.630)	(-0.469)	(2.680)
	20	1963	-0.032	-	0.019	-	0.299
		1981	(-0.664)	(-0.013)	(0.025)	(-)	(0.262)
	21	1963	-0.039	-0.013	0.025	-	0.262
		1981	(-0.819)	(-1.752)	(1.463)	(-)	(3.080)

t-statistic are in parentheses.

∗:significant at 10% level.

Table 11: Critical Values : Two Breaks

Series	Equation	1%	2.50%	5%	10%
Revenue	19	-5.03	-4.67	-4.38	-4.11
	20	-4.54	-4.27	-4.08	-3.79
	21	-4.93	-4.50	-4.36	-4.05
Expenditure	19	-5.05	-4.68	-4.43	-4.30
	20	-4.87	-4.54	-4.30	-4.05
	21	-4.94	-4.59	-4.36	-3.12

Table 12: Summary of Results

		Revenue			
Period	**Series**	**No. Of Breaks**	**Model**	**Dates of Break**	**Remarks**
British	$I(1)$	-	-	-	
Post Independence					
Nominal	$I(0)$	2	17	1963	Indo Chinese War
				1972	Indo-Pak War
Real	$I(0)$	1	18	1959	
		Expenditure			
Period	**Series**	**No. Of Breaks**	**Model**	**Dates of Break**	**Remarks**
British	$I(0)$	2	21	1905	Provincial Allocations made permanent
				1917	World War I
Post Independence					
Nominal	$I(0)$	1	21	1964	
Real	$I(0)$	1	17	1961	Indo-China War

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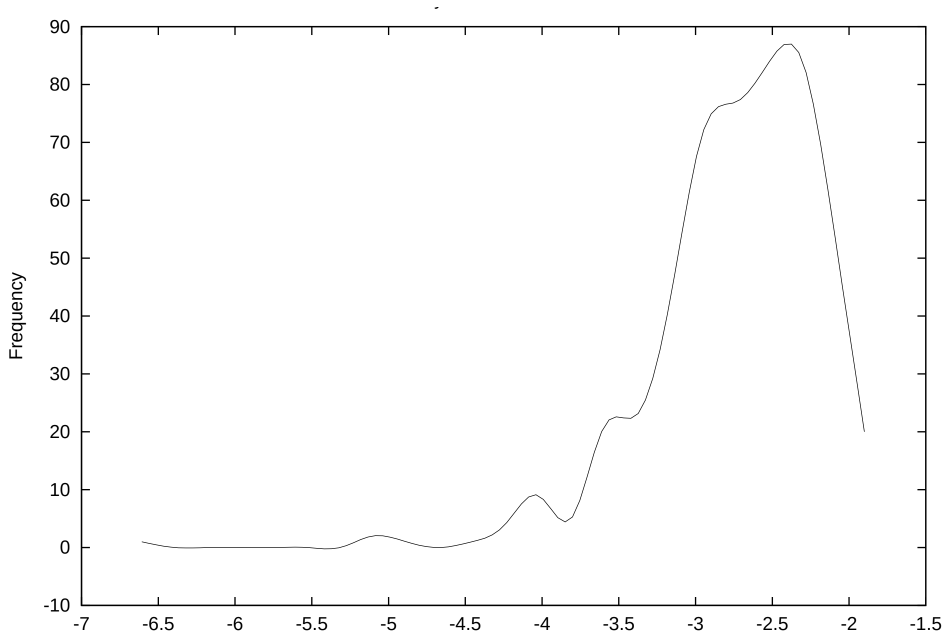

Figure 1: Density Plot of Critical Values: One Break Model

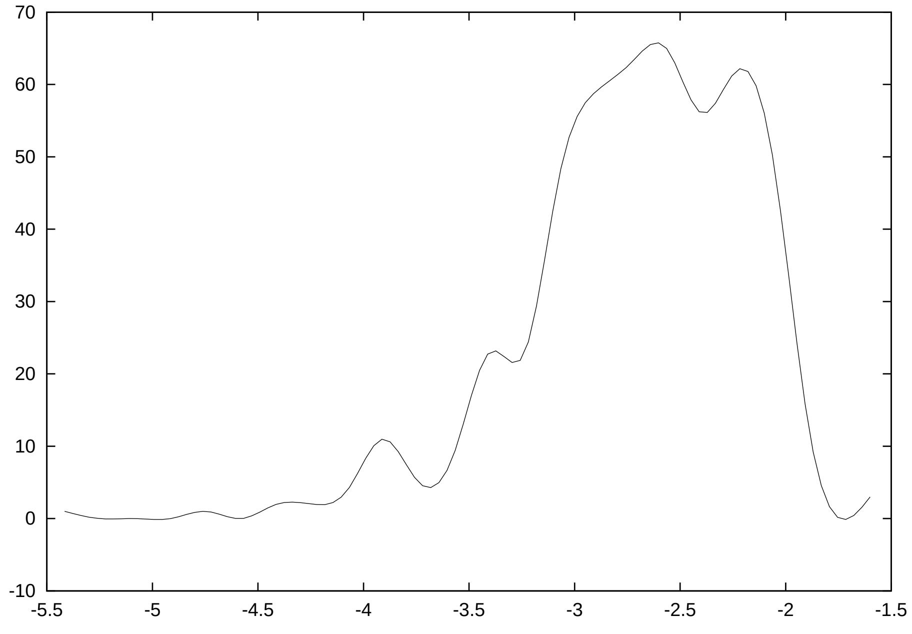

Figure 2: Density Plot of Critical Values: Two Breaks Model