A Nonlinear Approach to Public Finance Sustainability in Latin American Emerging Markets

by

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November 2004

Abstract

We analyze the sustainability of Latin American government debt. Our unit root tests incorporate nonlinear alternative hypotheses, which control for potential thresholds or corridor behavior due to international agreements or market pressure. Support for sustainability substantially improves when nonlinear mean-reversion is allowed.

Key Words: Fiscal policy, sustainability, nonlinearities.

JEL Classification: E6, H6, H87.

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The third author gratefully acknowledges financial support from the CUNY Collaborative Incentive Award.
1. Introduction and literature review

Fiscal imbalances are often catalysts to financial crises in highly indebted Latin American (LA) countries (Agenor and Montiel, 1999) and their correction has been in the heart of stabilization programs. While recent work explores institutional and political factors affecting fiscal performance, surprisingly little or no work exists focusing on the time-series properties of public debt/deficit to assess the sustainability of fiscal stances in this region. We evaluate the sustainability of fiscal policies in this region using stationarity tests that incorporate nonlinear processes. Our results overturn most of the nonstationarity findings obtained from traditional tests. The policy implications can be of great importance since a misguided assessment of public finance sustainability may require unnecessary painful stabilization action.

A typical empirical approach to fiscal policy sustainability is to examine the stationarity of the government debt or deficit. These tests, however, assume a continuous and constant-speed adjustment process and can be inadequate when fiscal variables exhibit a threshold behavior, biasing results to rejecting unit roots. In this paper, we use newly developed stationarity tests that allow the alternative hypothesis to incorporate nonlinearities, implying the presence of regimes within which the series may behave differently. The seemingly erratic behavior within a given set of values may not preclude mean-reversion once the series approaches some other values in its state space. A test failing to account for such behavior will wrongly interpret the meandering of the series within the band as evidence of nonstationarity.

This approach is motivated by the possibility that policymakers follow a rule whereby the debt/GDP ratio is kept below an implicit or explicit threshold imposed by markets or international institutions so that the reaction to debt accumulation can be different when debt is high or low. Policymakers take corrective action when the policy variable deviates from an acceptable value. This possibility of regimes is more pronounced in countries that face policy constraints reflecting international agreements and/or domestic stabilization programs as in all the five countries we consider. For example, recent legislative changes in the fiscal policy frameworks of many emerging market economies prescribe explicit ceilings for the government budget deficit in various forms of “Fiscal Responsibility/Transparency Laws” (IMF, 2001). Bertola and Drazen (1993) provide a different channel of nonlinear fiscal behaviour, emphasizing the signalling effects of drastic fiscal cuts and find that fiscal consolidation in several European countries is consistent with such behaviour. Fiscal adjustments attempting to offset the aggregate demand effects of capital-inflow-induced

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1 See Alesina, Hausmann, Hommes and Stein (1996), and Stein, Talvi and Grisanti (1998).
monetary expansion are another source of nonlinearities in emerging economies, which are vulnerable to massive capital flows swings.\(^2\)

Empirical assessments of fiscal policy sustainability employ various methodologies including a cointegrating relationship linking variables of the budget constraint,\(^3\) examining the feedback from debt to deficit,\(^4\) and testing the stationarity of the debt and/or deficit.\(^5\) Despite the econometric improvements (e.g., structural breaks, panel data), the bulk of the existing methodologies assume linearity. Recent work provides evidence on threshold effects in public debt using smooth transition autoregressive (STAR) models and reveals nonlinearities in fiscal policy (Sarno, 2001 and Cipollini, 2001). Such studies typically fit a STAR model assuming that the debt process itself is stationary. Our approach, however, is fundamentally different from them in that we test directly for the stationarity of the debt series.

2. Model, Methodology, and Data

Model: To examine if the government budget constraint holds in present value terms we start from:

\[ \Delta b_t = -s_t + \rho_t b_{t-1} \]  

(1)

where \(b\) is a measure of government debt, \(s\) is the seignorage inclusive primary surplus, and \(\rho\) is the ex-post interest rate on the outstanding stock of debt. Following earlier literature, we consider real debt, and debt normalized by GDP.\(^6\) Solving (1) forward assuming perfect foresight and successively substituting out the future discounted debt measure, gives the \(n\)-period intertemporal budget constraint:

\[ b_t = \delta_{t,n} b_{t+n} + \sum_{i=1}^{n} \delta_{t,i} s_{t+i} \]  

(2)

where \(\delta_{t,n} = \prod_{s=1}^{n} (1 + \rho_{t+s})^{-1}\) is the time-varying discount factor \(n\)-periods ahead. A necessary and sufficient condition for sustainability is that as \(n\) goes to infinity, the discounted value of the debt measure converges to zero. This transversality condition, which rules out Ponzi games, can be expressed as: \(\lim_{n \to \infty} \delta_{t+n} b_{t+n} = 0\). Thus, current debt is offset by the sum of current and future discounted surpluses, and the government budget constraint holds in present value terms.

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\(^6\) Each debt measure has a corresponding interest rate. If \(b\) is real debt (debt/GDP), then \(\rho\) is the real interest rate (the real interest rate adjusted for the growth rate of real GDP).
Methodology: We consider whether $b_t$ or its discounted version is stationary using unit-root tests that incorporate a nonlinear alternative. The first test, due to Kapetanios, Shin, and Snell (2002) henceforth KSS-, considers the null hypothesis of a unit root against the alternative of a STAR model in a context similar to DF test. We test for the null hypothesis of $\gamma = 0$ in the model:

$$\Delta b_t = \beta b_{t-1} (1 - e^{-\phi t_{t-1}}) + \epsilon_t. \tag{3}$$

The test is carried out by a $t$-test of the coefficient of $b^3_{t-1}$ being zero in the auxiliary regression

$$\Delta b_t = \alpha + \phi b^3_{t-1} + \epsilon_t. \tag{4}$$

In the presence of constants and trends, the data are first detrended/demeaned. The 1%, 5%, and 10% critical values for the detrended and demeaned data are –3.93, -3.40, and -3.13, respectively. We refer to this test as the non-linear augmented Dickey-Fuller (NLADF) test.

The second test uses an alternative detrending strategy as in Chortareas, Kapetanios, and Shin (2002) that combines the analysis of KSS and Schmidt and Phillips (1992) to derive a test of the unit root hypothesis against a smooth transition autoregressive alternative. Let the model be given by

$$b_t = \psi + \xi t + x_t. \tag{5}$$

$$\Delta x_t = \beta x_{t-1} (1 - e^{-\phi^2 t_{t-1}}) + \epsilon_t, \tag{6}$$

where $\beta < 0$, and $\epsilon_t$ is an i.i.d. error with finite variance $\sigma^2$. Under the null hypothesis $\gamma = 0$, the model is a unit root model whereas under the alternative it is a stationary nonlinear model. To test this hypothesis we construct an LM test following Schmidt and Phillips. This is given by a $t$-test of $\phi = 0$ in the regression

$$\Delta b_t = \alpha + \phi s^3_{t-1} + \epsilon_t \tag{7}$$

where $s_{t-1} = b_t - \bar{\psi} - \tilde{\xi}(t-1)$ and $\bar{\tilde{\xi}} = (b_T - b_1)/(T-1)$, $\tilde{\psi} = b_1 - \bar{\tilde{\xi}}$. Under the null hypothesis, the asymptotic distribution of

$$\tau = \frac{\sum_{t=1}^{T} (s^3_{t-1} - s^3) \epsilon_t}{\hat{\sigma} \sqrt{\sum_{t=1}^{T} (s^3_{t-1} - s^3)}^{1/2}} \tag{8}$$

is given by $\tau \Rightarrow \int V(r) dW(r) \int V^2(r) dr$, where $\hat{\sigma}$ is the estimated standard error of the regression, $s^3$ is the mean of $s_t$, $W(r)$ is a standard Brownian motion, $V(r)$ is a standard Brownian bridge and $V(r) = V(r)^3 - \int V(r)^3 dr$. To deal with the issue of possible weak dependence in $\epsilon_t$, regression (7) is augmented with lags of $\Delta b_t$ following the approach of DF and Ng and Perron (1995). The
asymptotic distribution of the test does not change and the results of Ng and Perron (1995) concerning data dependent selection of the lag order for the lag polynomial in $\Delta h_t$ carry over to this case (see KSS, 2002). We refer to this test as the nonlinear Schmidt-Phillips (NLSP) test. The 1%, 2.5%, 5%, 10% critical values of the test are -3.52, -3.23, -3.00, and -2.73, respectively.\(^7\)

**Data:** The countries in the sample are Mexico, Costa Rica, El Salvador, Guatemala, Panama, Honduras, and their choice has been dictated by the availability of data. Debt measures used in this study are real debt, debt/GDP ratio, and compound discounted real debt with inflation-adjusted discount rate.\(^8\) Debt measures are constructed with data from the *International Financial Statistics* and the *Government Financial Statistics* of the IMF on nominal government debt, GDP deflator, nominal GDP (GNP when GDP not available), and interest rate.\(^9\) Interest rate series are computed as the geometric average of the market interest rates at a given date. The inflation rate is calculated as a centered moving average with four lags and leads.

### 3. Results

We present our results in Tables 1, 2, and 3. All tables have the same structure. The first three columns provide the results of the standard DF and ADF tests. We consider two versions of the ADF test corresponding to different optimal lag-length selection procedures. The first, ADF(4), assumes four lags while the second, ADF(A), employs an automated process for selecting the optimal number of lags. The next three columns provide the results of the unit-root tests that incorporate a nonlinear alternative in the form of an Exponential Smooth Transition Autoregressive (ESTAR) process. The three specifications correspond to those of the first three (standard) stationarity tests and are labeled NLDF, NLADF(4), and NLDF(A), respectively. The last three columns provide the results of the nonlinear tests where the alternative hypothesis represents a geometrically ergodic process defined by a Self-Exciting Threshold Autoregressive (SETAR) model with three regimes, labeled NLSP, NLASP(4), and NLASP(A), respectively.

In Table 1 the typical DF and ADF tests point unequivocally to the presence of unit roots in the undiscounted real debt processes in all sample countries. All six nonlinear tests, however, dispute

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\(^7\) The critical values for this test and the NLADF test have been obtained by simulation. See KSS and Chortareas, Kapetanios and Shin (2002).

\(^8\) We do not use the discounted debt/GDP ratio because in high inflation/growth economies adjusting the real rate for real-GDP growth, required to discount the debt/GDP, sometimes gives a negative discount rate that gets compounded in the measurement. Thus the resulting debt measure becomes meaningless.

\(^9\) The debt and the interest rate data are quarterly, starting from 1970 to 1986, and ends at 2000. The GDP data are often annual. To ensure efficient use of the statistical tests, we converted the annual data to quarterly using a cubic transformation.
this picture and indicate stationarity (with the exception of NLSP) in up to three out of the five countries considered (Costa Rica, Honduras, and Mexico).

Although the literature commonly analyzes government debt in real terms, in practice financial analysts often refer to a compound present-value concept of real debt, while the popular press reports government debt as a ratio to GDP. As with the real debt measures, the debt/GDP ratio results from the DF and ADF specifications in Table 2 show nonstationarity. In contrast, both versions of nonlinear unit-root tests reveal a substantially different outcome with the NLADF(4) and the NLASP(4) tests showing mean reversion in up to three out of five countries.

Finally, Table 3 provides the results from applying the same set of tests to compound discounted real debt measures. Although the DF and ADF tests now show some limited evidence of mean-reversion (El Salvador) the non-linear tests (NLADF(4), NLASP(4), NLADF(A), and NLASP(A)) provide again stronger evidence of stationarity in the debt of up to three countries.

Overall, the nonlinear tests reverse the traditional test results, providing enhanced evidence for sustainability in Mexico, Honduras, Costa Rica, and El Salvador. The evidence for debt stationarity suggested by the nonlinear tests is weaker for Guatemala. Depending on the debt measure and the model, we are able to find mean reversion in up to three out of five countries where the standard tests showed none.

4. Conclusion
Curbing the accumulation of public debt is a typical component of stabilization policies in the emerging markets of LA. However, one can hardly find evidence that address the sustainability of public finances in those countries, which focus on the time series properties of the debt/deficit measures. We test for public debt stationarity by using unit root tests with a nonlinear alternative hypothesis and find that most of the nonstationarity results obtained from traditional tests can be overturned. Our results indicate that the standard stationarity tests may underestimate the sustainability of public debt and even trigger unnecessary policy actions. Moreover, a complete assessment of public finance sustainability that avoids excessively optimistic or pessimistic views needs to rely on more than a single type of empirical test. Finally, our results motivate further work on the explicit modeling of nonlinearities, which is beyond the scope of the present letter.
References

International Monetary Fund, (2001) *World Economic Outlook*, May, IMF.
Table 1: Stationarity of real debt

<table>
<thead>
<tr>
<th></th>
<th>DF</th>
<th>ADF</th>
<th>ADF(A)</th>
<th>NLDF</th>
<th>NLADF(4)</th>
<th>NLADF(A)</th>
<th>NLSP</th>
<th>NLASP(4)</th>
<th>NLASP(A)</th>
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</thead>
<tbody>
<tr>
<td>Costa Rica</td>
<td>-1.267</td>
<td>-0.876</td>
<td>-1.033</td>
<td>-2.564</td>
<td>-2.232</td>
<td>-2.228</td>
<td>-1.214</td>
<td>-1.015*</td>
<td>-1.038</td>
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<td>Guatemala</td>
<td>-1.166</td>
<td>-2.369</td>
<td>-2.178</td>
<td>-0.932</td>
<td>-2.537</td>
<td>-2.341</td>
<td>-0.833</td>
<td>-2.584</td>
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DF (ADF) is the Dickey-Fuller (augmented DF) test, NLDF and NLADF are the nonlinear DF and ADF tests, NLSP and NLASP are the nonlinear Schmidt-Phillips test and its augmented version. X(4) assumes four lags, X(A) selects an optimal number of lags. The 1%, 5% and 10% critical values are –3.93, -3.40, -3.13 for the NLADF tests, and the 1%, 2.5%, 5% and 10% critical values are –3.52, -3.23, -3.00, -2.73 for the NLSP tests.

Table 2: Stationarity of Debt/GDP

<table>
<thead>
<tr>
<th></th>
<th>DF</th>
<th>ADF(4)</th>
<th>ADF(A)</th>
<th>NLDF</th>
<th>NLADF(4)</th>
<th>NLADF(A)</th>
<th>NLSP</th>
<th>NLASP(4)</th>
<th>NLASP(A)</th>
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<td>El Salvador</td>
<td>-1.204</td>
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<td>-1.715</td>
<td>-1.637</td>
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<td>-2.348</td>
<td>-1.602</td>
<td>-1.671</td>
<td>-1.366</td>
<td>-1.143</td>
<td>-1.275</td>
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</table>

See footnote Table 1.

Table 3: Stationarity of compound discounted real debt

<table>
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<th>DF</th>
<th>ADF(4)</th>
<th>ADF(A)</th>
<th>NLDF</th>
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<th>NLADF(A)</th>
<th>NLSP</th>
<th>NLASP(4)</th>
<th>NLASP(A)</th>
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<tbody>
<tr>
<td>Costa Rica</td>
<td>-0.130</td>
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<td>-1.564</td>
<td>-0.654</td>
<td>-2.895</td>
<td>-3.782*</td>
<td>-1.436</td>
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<td>-4.458**</td>
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<td>Guatemala</td>
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<td>-1.888</td>
<td>-1.176</td>
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<td>Mexico</td>
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<td>-2.756</td>
<td>-0.858</td>
<td>-3.533*</td>
<td>-3.932**</td>
<td>-1.245</td>
<td>-2.547</td>
<td>-2.990*</td>
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</table>

See footnote Table 1.