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## An Investigation of Current Account Solvency in Latin America Using Non Linear Stationarity Tests

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# An Investigation of Current Account Solvency in Latin America Using Non Linear Stationarity Tests

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## Abstract

Using a new methodology that allows for nonlinearities, we find frequent support for sustainability in the debt of a set of Latin American countries. Our findings overturn results obtained with traditional unit-root tests and provide a more realistic alternative to evaluate the external solvency of an economy.

*Keywords:* Current Account, Nonlinearity

*JEL Codes:* C22, F32, F34

## 1 Introduction

Most Latin American (LA) countries entered the 1970s with high debt ratios, gradually declining until the 1980 debt crisis. Since then, debt has been steadily rising and recently reached pre-crisis levels (see Figure 1). Are

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these debt levels sustainable? Will they lead to another crisis in the future? Despite a large body of literature focusing on stabilization programs in LA, sustainability of the region's debt has received little attention. We address these questions by analyzing the solvency of external imbalances in LA.

Our contribution to the literature is two-fold: (i) we focus on a region whose external debt has been under the scrutiny of international investors and institutions; (ii) we use a new methodology that allows for nonlinearities in debt. Our results support sustainability in the majority of the cases, overturning results obtained with traditional tests.

The solvency of a country is typically analyzed by testing whether its national intertemporal budget constraint (IBC) holds in present value terms. Previous studies emphasize industrialized economies, and are inconclusive due to differences in methodology, approach and sample.<sup>1</sup> These studies formulate alternative hypotheses about linear models. However, inspection of debt patterns in LA suggests that these economies may be subject to policy constraints due to international constraints and domestic stabilization programs, implying nonlinearities. Our tests incorporate nonlinear alternative hypotheses that capture "corridor regime" behavior. This substantially improves upon standard stationarity tests that may classify as nonstationary series that behave differently inside and outside of fixed bands.

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<sup>1</sup>Sustainability of the US IBC is rejected by Trehan and Walsh (1991), and Fountas and Wu (1999) but not by Wickens and Uctum (1993), Ahmed and Rogers (1995), and Husted (1992). Liu and Tanner (1996), using structural breaks, and Wu (2000), Wu, Chen and Lee (2001), using panel techniques, find that industrial countries' external debt is sustainable.

## 2 Theory

We start with a stylized version of the nominal balance of payments identity defined in domestic currency:

$$E_t \Delta B_t^* - \Delta B_t^f = T_t + i_t^* E_t B_{t-1}^* - i_t B_{t-1}^f \quad (1)$$

with  $T$ : trade balance,  $B^f(B^*)$  domestic (foreign) assets held by foreigners (domestic residents),  $i, i^*$ : nominal rate of return on domestic (foreign) asset, and  $E$ : the domestic price of the foreign exchange rate. Deflating by nominal GDP, and regrouping terms, we can rewrite the identity as:

$$\Delta f_t = c_t + \tilde{r}_t f_{t-1} \quad (2)$$

where  $c_t = t_t + (i_t - i_t^* - \dot{e}_t) b_{t-1}^*$  is the primary current account deficit,  $f_t = b_t - b_t^*$  is net foreign indebtedness, and  $\tilde{r}_t = i_t - \dot{p}_t - \dot{y}_t$  is the growth-adjusted real return on net foreign debt. Further,  $\dot{e} = \Delta \log E_t$ ,  $\dot{p} = \Delta \log P_t$ , and  $\dot{y} = \Delta \log Y_t$ , all other lower case letters denote variables as a ratio to nominal GDP. If (2) is deflated by a price index,  $f$  and  $c$  are real foreign debt and current account, and  $\tilde{r}$  is the real interest rate. Assuming  $\tilde{r} > 0$ , solving (2) forward, and imposing the no-Ponzi game condition, the IBC is:

$$f_t = - \sum_{i=1}^n \rho_t c_{t+i} \quad (3)$$

with  $\rho_t = \prod_{s=1}^n (1 + \tilde{r}_{t+s})^{-1}$ . If this condition holds, current and future discounted primary trade surpluses are sufficient to pay off initial indebtedness. The traditional sustainability approach applies the DF tests on  $f_t$  or on its discounted version and tests if it is stationary.

## 3 Data

The sample consists of Argentina, Bolivia, Brazil, Chile, Colombia, El Salvador, Guatemala, Mexico, Nicaragua, Panama, Peru, and Venezuela. We

analyze two common debt measures: real debt and debt/GDP ratio. Because compound discounting creates measurement problems in high-inflation economies, we limit the analysis to simple debt/GDP ratios, real debt, and their simple discounted versions. We construct all four debt measures with: US dollar denominated external debt and nominal GDP, the bilateral dollar exchange rate, the GDP deflator, and the interest rate. The series come from the International Financial Statistics and the Balance of Payments Statistics of the IMF and are quarterly, except the annual debt series. Due to unavailability of quarterly debt series in LA, we converted the annual data to quarterly using a linear transformation. This affects all tests symmetrically and should not introduce any measurement bias in interpreting the results. For interest rate series that reflect the market rates, we computed the geometric average of the existing rates at each date. We calculate the inflation rate as a centered moving average with four lags and leads.

## 4 Econometric Methodology

Here we follow the framework of Kapetanios and Shin (2002) (KS) who deal with threshold models along the lines of previous work by Kapetanios, Shin and Snell (2002) on smooth nonlinear models. More specifically, we consider the model,

$$\Delta y_t = \beta_1 y_{t-1} 1_{\{y_{t-1} \leq r_1\}} + \beta_2 y_{t-1} 1_{\{y_{t-1} > r_2\}} + u_t, \quad (4)$$

where  $-2 < \beta_1 < 0$ ,  $-2 < \beta_2 < 0$  and  $\epsilon_t$  is an iid error with zero mean and constant variance  $\sigma^2$ . The null hypothesis is of the form  $\beta_1 = \beta_2 = 0$  against the alternative hypothesis  $\beta_1 < 0$  or  $\beta_2 < 0$ . Under the null  $y_t$  follows a linear unit root process, whereas it is nonlinear stationary SETAR process under the alternative. SETAR processes allow for sudden changes

in the evolution of the process depending on its past history and for varying degrees of persistence depending on the current state of the process.

Writing (4) in matrix notation gives

$$\Delta \mathbf{y} = \mathbf{X}\beta + \mathbf{u}, \quad (5)$$

where  $\beta = (\beta_1, \beta_2)'$ , and

$$\Delta \mathbf{y} = \begin{pmatrix} \Delta y_1 \\ \Delta y_2 \\ \vdots \\ \Delta y_T \end{pmatrix}; \quad \mathbf{X} = \begin{pmatrix} y_0 \mathbf{1}_{\{y_0 \leq r_1\}} & y_0 \mathbf{1}_{\{y_0 > r_2\}} \\ y_1 \mathbf{1}_{\{y_1 \leq r_1\}} & y_1 \mathbf{1}_{\{y_1 > r_2\}} \\ \vdots & \vdots \\ y_{T-1} \mathbf{1}_{\{y_{T-1} \leq r_1\}} & y_{T-1} \mathbf{1}_{\{y_{T-1} > r_2\}} \end{pmatrix}; \quad \mathbf{u} = \begin{pmatrix} u_1 \\ u_2 \\ \vdots \\ u_T \end{pmatrix}.$$

Then, the joint null hypothesis of linear unit root against the nonlinear threshold stationarity can be tested using the Wald statistic given by

$$\mathcal{W}_{(r_1, r_2)} = \hat{\beta}' \left[ \text{Var} \left( \hat{\beta} \right) \right]^{-1} \hat{\beta} = \frac{\hat{\beta}' (\mathbf{X}' \mathbf{X}) \hat{\beta}}{\hat{\sigma}_u^2}, \quad (6)$$

where  $\hat{\beta}$  is the OLS estimator of  $\beta$ ,  $\hat{\sigma}_u^2 \equiv \frac{1}{T-2} \sum_{t=1}^T \hat{u}_t^2$ , and  $\hat{u}_t$  are the residuals obtained from (4).

The test suffers from the Davies (1987) problem since unknown threshold parameters are not identified under the null. Most solutions to this problem entail integrating out unidentified parameters from the test statistics. This is achieved by examining some summary statistic obtained over a grid of values for the nuisance parameters. For stationary TAR models this problem has been studied in Tong (1990) and Hansen (1996). Following Andrews and Ploberger (1994), KS consider the three commonly used statistics, i.e. the supremum, the average and the exponential average of the Wald statistic defined respectively by

$$\mathcal{W}_{(r_1, r_2)}^{\text{sup}} = \sup_{i \in \# \Gamma} \mathcal{W}_{(r_1, r_2)}^{(i)}, \quad \mathcal{W}_{(r_1, r_2)}^{\text{avg}} = \frac{1}{\# \Gamma} \sum_{i=1}^{\# \Gamma} \mathcal{W}_{(r_1, r_2)}^{(i)}, \quad \mathcal{W}_{(r_1, r_2)}^{\text{exp}} = \frac{1}{\# \Gamma} \sum_{i=1}^{\# \Gamma} \exp \left( \frac{\mathcal{W}_{(r_1, r_2)}^{(i)}}{2} \right), \quad (7)$$

Table 1: Asymptotic Critical Values of the  $\mathcal{W}_{(r_1, r_2)}$  Statistic

	Case 1	Case 2	Case 3
90%	6.01	7.29	10.35
95%	7.49	9.04	12.16
99%	10.94	12.64	16.28

where  $\mathcal{W}_{(r_1, r_2)}^{(i)}$  is the Wald statistic obtained from the  $i$ -th point of the nuisance parameter grid,  $\Gamma$  and  $\#\Gamma$  is the number of elements of  $\Gamma$ . KS find that the exponential Wald statistic performs best and so we consider this statistic only. We construct an  $8 \times 8$  equally spaced grid between the 10% and 50percentile for the lower and upper threshold respectively for the empirical results. Further details on the selection of the grid are available in KS.

The asymptotic distributions of  $\mathcal{W}_{(r_1, r_2)}^{sup}$  and  $\mathcal{W}_{(r_1, r_2)}^{avg}$  are the same and are given by the distribution of

$$\mathcal{W} \equiv \frac{\left\{ \int_0^1 1_{\{W(s) \leq 0\}} W(s) dW(s) \right\}^2}{\int_0^1 1_{\{W(s) \leq 0\}} W(s)^2 ds} + \frac{\left\{ \int_0^1 1_{\{W(s) > 0\}} W(s) dW(s) \right\}^2}{\int_0^1 1_{\{W(s) > 0\}} W(s)^2 ds},$$

where  $W(s)$  is a standard Brownian motion. It can be proven that for all finite  $r_1$  and  $r_2$ ,  $\mathcal{W}_{(r_1, r_2)} \xrightarrow{p} \mathcal{W}_{(0, 0)}$  and also that the process  $\mathcal{W}_{(r_1, r_2)}^{(i)}$  is stochastically equicontinuous (see KS) implying that  $\mathcal{W}_{(r_1, r_2)}^{avg} \xrightarrow{p} \mathcal{W}_{(0, 0)}$  and  $\mathcal{W}_{(r_1, r_2)}^{exp} \xrightarrow{p} e^{\mathcal{W}_{(0, 0)}/2}$ .

We deal with constants and trends by demeaning and detrending the data before applying the test. Then, the asymptotic distribution of the test changes because the standard demeaned or the detrended Brownian motion appear rather than the standard Brownian motion. Table 1 taken from KS, presents selected fractiles of the asymptotic critical values, tabulated using 5,000 random walks and 50,000 replications. Finally, we correct for serial

correlation in  $\epsilon_t$  by augmenting the testing equation with lags of  $\Delta y_t$ . The asymptotic distributions under the null hypothesis do not change.

## 5 Empirical Results

We have tested for nonlinearity in the following series: real debt, debt/GDP ratio, simple discounted real debt and debt/GDP ratio. We denote tests on the demeaned and detrended series by the superscripts  $\mu$  and  $\tau$  respectively in the test name. The order of the lag augmentation carried out to remove serial correlation is denoted by the subscript for each test. We also report results for the Dickey-Fuller (DF)<sup>2</sup> test of nonstationarity. Results are reported in Tables 2 to 5. Daggered entries indicate significance at the 10% significance level. Starred entries indicate rejection at the 5% significance level.

The new tests' findings are striking: nonstationarity is rejected in eleven countries out of twelve at the 5% significance level, in at least one debt measure with one of the test specifications. This contrasts with only three rejections with DF tests. More specifically, for real debt, SETAR tests reject nonstationarity in seven (eight) out of twelve countries at the 5% (10%) significance level with at least one lag specification. DF tests reject only in two countries (Table 2). For debt/GDP ratios, rejections occur in 1/4 of the cases with the SETAR tests compare with 1/12 with DF (Table 3). Discounting both debt measures leads to five (eight) rejections at the 5% (10%) level, with SETAR tests, which dominates the three (five) rejections by DF tests (Table 4 and 5).

At the country level, and 10% significance, nonstationarity in Panama is consistently rejected with both tests and debt measures. SETAR tests reject nonstationarity in Argentina, Brazil, and Nicaragua for three debt measures,

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<sup>2</sup>We use DF to denote both DF and ADF tests

and in Bolivia, Columbia, El Salvador, Mexico, Peru and Venezuela for two debt measures. DF tests only reject it in Bolivia and Peru.

## 6 Conclusion

Using a new methodology that allows for nonlinearities, we find frequent support for sustainability in the LA debt. Our findings overturn results obtained with traditional unit-root tests and provide a more realistic alternative to evaluate the external solvency of an economy.

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Table 2: Test Results For Real External Debt<sup>a</sup>.

Country	$DF_0^\mu$	$DF_0^\tau$	$DF_4^\mu$	$DF_4^\tau$	$\mathcal{W}_0^{exp,\mu}$	$\mathcal{W}_0^{exp,\tau}$	$\mathcal{W}_4^{exp,\mu}$	$\mathcal{W}_4^{exp,\tau}$
Argentina	0.174	-1.352	0.095	-1.429	1.307	5.647	1.396	5620.41*
Bolivia	-0.485	-1.236	-1.264	-2.859	1.846	2.214	9.999	73.656
Brazil	0.512	-0.251	-1.116	-2.183	338.350*	1.252	2.053	17.176
Chile	0.634	-0.552	-0.969	-2.254	25.011	1.279	3.412	11.780
Colombia	1.961	-0.364	0.195	-1.890	410323.8*	1.329	1.563	8.577
El Salvador	-0.136	4.158	-2.038	-0.781	2.680	30199090*	78.760 <sup>†</sup>	10.282
Guatemala	-0.098	-1.084	-0.425	-1.519	8.983	2.125	2.528	6.822
Mexico	-1.523	-0.717	-1.822	-1.799	3.091	1.660	53.346 <sup>†</sup>	9.302
Nicaragua	-2.458	-2.946	-2.438	-1.811	29.600	142.376	1488.864*	440.467*
Panama	-3.478*	-0.572	-2.172	-1.530	26854.49*	1.282	8.112	4.971
Peru	-1.329	-1.756	-1.546	-2.319	2.271	5.510	10.146	45.846
Venezuela	-0.180	6.53	-0.806	3.208 <sup>†</sup>	1.121	20873053*	1.980	3476.914*
No. of Rejections	1	0	0	1	3	2	3	3

<sup>a</sup>We denote tests on the demeaned and detrended series by the superscripts  $\mu$  and  $\tau$  in the test name. The order of the lag augmentation carried out to remove serial correlation is denoted by the subscript for each test. Daggered entries indicate significance at the 10% significance level. Starred entries indicate rejection at the 5% significance level.

Table 3: Test Results For Debt/GDP Ratio.

Country	$DF_0^\mu$	$DF_0^\tau$	$DF_4^\mu$	$DF_4^\tau$	$\mathcal{W}_0^{exp,\mu}$	$\mathcal{W}_0^{exp,\tau}$	$\mathcal{W}_4^{exp,\mu}$	$\mathcal{W}_4^{exp,\tau}$
Argentina	-1.107	-1.235	-1.194	-1.291	3.918	5.806	21.573	132.142
Bolivia	-1.201	-1.101	-1.605	-1.601	3.178	2.833	7.488	7.524
Brazil	-1.825	-1.275	-2.141	-2.006	8.144	2.563	9.186	13.486
Chile	-1.058	-0.864	-2.008	-1.916	1.668	1.385	7.247	5.227
Colombia	-0.060	-0.690	-1.412	-1.877	1.077	1.226	2.554	4.638
El Salvador	-1.748	-0.489	-1.745	-1.394	6.717	1.165	5.713	3.516
Guatemala	-1.341	-0.177	-1.350	-0.903	3.085	3.120	110.230*	115.020
Mexico	-1.300	-0.700	-2.055	-1.870	2.287	1.572	32.161	13.791
Nicaragua	-1.036	-0.382	-1.809	-2.017	1.716	2.154	10.995	21.478
Panama	-2.941*	-0.227	-2.461	-1.867	164.449*	1.375	17.273	53.934
Peru	-1.438	-1.353	-1.540	-1.388	3.557	4.258	10.792	12.088
Venezuela	-1.017	2.452	-1.102	1.888	1.917	3174.997*	4.617	127.089
No. of Rejections	1	0	0	0	1	1	1	0

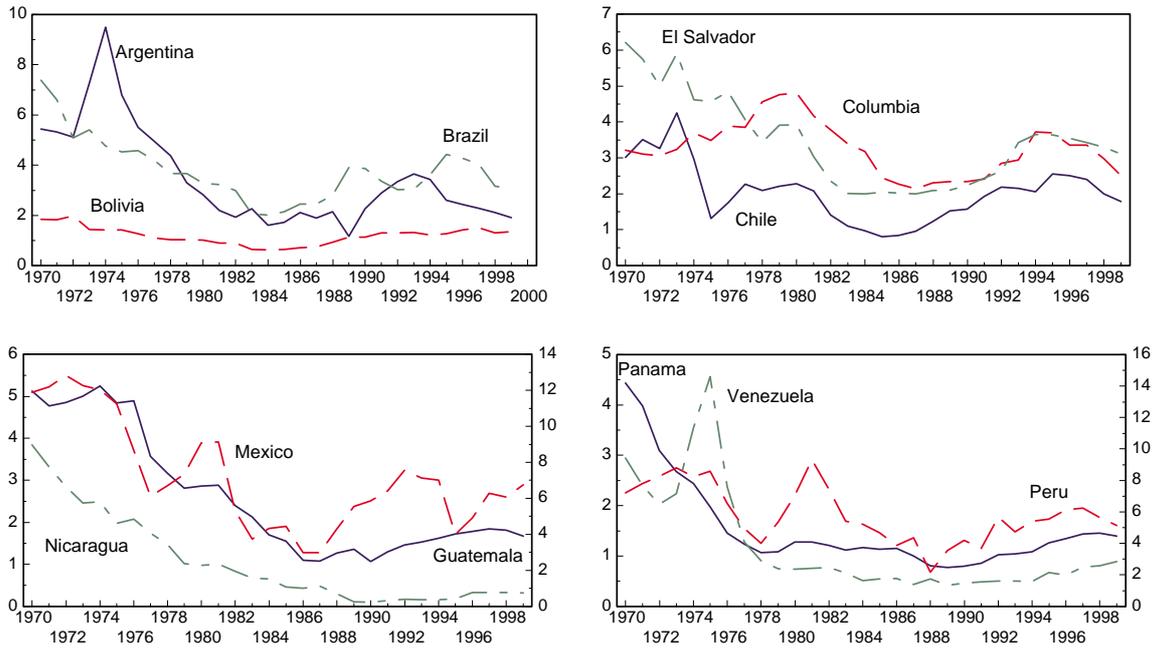
Table 4: Test Results For Discounted Real Debt.

Country	$DF_0^\mu$	$DF_0^\tau$	$DF_4^\mu$	$DF_4^\tau$	$\mathcal{W}_0^{exp,\mu}$	$\mathcal{W}_0^{exp,\tau}$	$\mathcal{W}_4^{exp,\mu}$	$\mathcal{W}_4^{exp,\tau}$
Argentina	-0.451	-2.990	-0.442	-2.455	437.416*	674.258*	231.871*	165.245
Bolivia	-3.199*	-3.639*	-2.322	-2.880	315.959*	1497.747*	31.881	133.486
Brazil	-2.567	-3.194 <sup>†</sup>	-1.155	-1.773	72.964 <sup>†</sup>	282.395 <sup>†</sup>	24.466	19.427
Chile	-0.685	-1.627	-1.975	-3.285	3.274	3.515	16.115	241.425 <sup>†</sup>
Colombia	1.262	-0.428	0.480	-1.442	24.198	1.335	1.445	12.431
El Salvador	-2.394	-2.133	-2.277	-1.799	91.277 <sup>†</sup>	51.252	111.727*	70.532
Guatemala	-0.162	-1.232	-1.446	-0.410	6.763	3.042	2.268	4.928
Mexico	-1.458	-1.795	-1.643	-2.294	4.129	9.304	8.566	35.893
Nicaragua	-2.460	-2.943	-2.369	-1.788	22.021	140.606	85.659 <sup>†</sup>	302.753 <sup>†</sup>
Panama	-3.368*	-0.999	-2.335	-1.775	1540.923*	1.936	6.173	19.825
Peru	-5.042*	5.053*	-3.353*	-3.352 <sup>†</sup>	10508480*	74278034*	93751.38*	61894.96*
Venezuela	-0.907	0.214	-1.231	0.069	2.074	1.218	5.768	1.614
No. of Rejections	3	3	1	1	6	4	4	3

Table 5: Test Results For Discounted Debt/GDP Ratio

Country	$DF_0^\mu$	$DF_0^\tau$	$DF_4^\mu$	$DF_4^\tau$	$\mathcal{W}_0^{exp,\mu}$	$\mathcal{W}_0^{exp,\tau}$	$\mathcal{W}_4^{exp,\mu}$	$\mathcal{W}_4^{exp,\tau}$
Argentina	-1.106	-2.817	-1.126	-2.506	14921.13*	2253.224*	13915.75*	606.022*
Bolivia	-4.016*	-5.011*	-1.387	-2.117	28567.93*	15246115*	7.396	75.866
Brazil	-2.628 <sup>†</sup>	-2.580	-1.414	-1.260	49.815 <sup>†</sup>	45.184	4.687	4.589
Chile	-1.579	-1.527	-2.562	-2.536	2.633	2.564	22.838	27.188
Colombia	-1.033	-0.841	-1.693	-1.471	3.526	2.912	257.610*	284.170 <sup>†</sup>
El Salvador	-1.641	-0.939	-1.688	-1.480	4.725	2.196	4.863	34.514
Guatemala	-1.294	-0.358	-1.337	-0.977	2.303	1.811	7.541	7.063
Mexico	-1.754	-1.673	-2.498	-2.888	10.217	12.379	621.235*	897.102*
Nicaragua	-1.825	-2.026	-2.395	-3.018	3.488	10.945	14.179	220.066 <sup>†</sup>
Panama	-2.807 <sup>†</sup>	-0.194	-2.506	-1.826	60.262 <sup>†</sup>	1.447	15.810	25.257
Peru	-1.730	-1.707	-2.768 <sup>†</sup>	-2.804	11.231	13.941	505.228*	1104.431*
Venezuela	-0.925	0.652	-1.022	0.362	2.236	3.761	8.368	4.111
No. of Rejections	3	1	1	0	4	2	4	5

**Figure 1: External Debt/GDP**



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