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Do Real Exchange Rates Follow a Non-Linear Mean Reverting Process in Developing Countries?

ABSTRACT

In an effort to fight inflation, many countries try manage their nominal exchange rates. One way of testing whether such a policy is successful is to determine whether the nominal exchange rate and relative prices converge in the long-run which implies the real exchange rate must be stationary or mean reverting. If they are mean reverting, the well-known theory of Purchasing Power Parity (PPP) is validated. In this paper we test the null of nonstationarity versus an alternative of linear stationarity by the means of standard ADF test and compare the results to those obtained from a new test in which the null is the same but the alternative hypothesis is non-linear stationarity by employing monthly real effective exchange rate data from 88 developing countries. The latter test supports the PPP theory in twice as many countries as the former test. The two combined validate PPP in 44 developing countries.

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I. Introduction

The debate on the validity of the purchasing power parity (PPP) hypothesis continues. To test PPP, many researchers rely on evidence from unit root tests regarding the (non) stationarity of real exchange rates (RER). Initial studies, which were based on the augmented Dickey-Fuller (ADF) tests, showed evidence against the theory. The failure of validating PPP has been attributed to the low power of these tests. As a result, the literature has moved on in two new directions: While some researchers have turned to panel unit root tests, others have proposed alternative tests that emphasize a nonlinear stationary process.[1]

Using either a panel or a nonlinear unit root tests, several studies have provided fresh evidence on the validity of PPP.[2] However, these studies focus mainly on industrial countries. Empirical evidence on PPP in developing countries has been scant, especially using the recent tests that have higher power against the initial ADF tests. In the present paper, we fill this gap in the literature by providing comprehensive evidence on the validity of PPP for 88 developing economies. To do so, we use the recently developed nonlinear smooth transition autoregressive (ESTAR) procedure developed in Kapetanios, Shin and Snell (KSS, hereafter) (2003). They have developed a new technique for the null hypothesis of a unit root against an alternative of nonlinear STAR process. Assuming real exchange rates follow nonlinear stationary processes, the alternative hypothesis of the ADF unit root tests based on the linear model would be misspecified. KSS (2003) have illustrated that their tests are more powerful than the ADF tests.

[1] For a review of literature, see Lothian and Taylor (2005) and Sarno (2005).

[2] Panel unit root studies, among others, include Papel and Theodoridis (2001) and Alba and Park (2003). Taylor et al. (2001), Kapetanios et al. (2003), Chortareas and Kapetanios (2004), Sarno et al. (2004) and Lothian and Taylor (2005), among others, employ nonlinear real exchange rate adjustment models to solve the so called PPP puzzle, which suggests that PPP does not even hold in the long run.

Evidence on the validity of PPP in developing countries is scant. To our knowledge, the most comprehensive evidence comes from a recent study by Alba and Park (2003).[3] They provide evidence from 65 developing countries during the 1976-1999 period. They find weak evidence on PPP and PPP tends to hold better for the post-80 period. Our study provides complementary evidence on their findings regarding the validity of PPP in developing economies in the following sense. While Alba and Park (2003) use panel unit root tests, we base our evidence on the nonlinear ESTAR tests.[4] If RERs exhibit nonlinear behavior, panel unit root tests that assume linear behavior may bias the inferences.[5]

Besides using a different approach, our study is also different from the Alba and Park (2003) in terms of the definition of the real exchange rate we employ: We use real effective exchange rates (REERs) in our analysis, while they employ bilateral RERs against the US dollar. Unit root tests on REERs sets a more comprehensive stage to test PPP because they indicate movement in the overall value of a country's currency rather than a movement against the currency of only one trading partner embodied in the real bilateral exchange rate. Testing whether REERs follow non-stationary mean reverting behavior is also a test of the multi-country version of PPP, rather than that of PPP based on a bilateral trading partner. Overall, we offer complementary evidence on the legitimacy of PPP in developing countries using an alternative

[3] Other notable studies are Sarno (2000) and Liew et al. (2004). They test PPP for 11 Middle East and 11 Asian countries, respectively. Like ours, both studies use nonlinear unit root tests. They find more evidence supporting PPP than in cases when ADF tests are employed.

[4] The key reason why we prefer to use nonlinear tests in this paper over panel unit root tests is because there are good theoretical reasons why RERs might exhibit a nonlinear adjustment process. One potential source arises from nonlinearities in international goods arbitrage because of factors such as trade barriers, causing a price gap among similar goods traded in spatially separated markets. Other reasons include foreign exchange rate interventions during periods of floating exchange rate systems and different beliefs among market participants regarding equilibrium level of real exchange rates. Lothian and Taylor (2005) provide a summary of these theories and review corresponding empirical studies. Overall, evidence indicates that RERs exhibit nonlinear adjustment patterns.

[5] Alba and Park (2003) also report some ADF test results as some preliminary evidence to their panel unit root tests. Hence, our results based on nonlinear adjustment processes may be considered as an extension of their ADF tests.

approach (nonlinear ESTAR) than Alba and Park (2003) and a multi-country framework. We also discuss whether the membership of a country in a trade association has some impact on the time series behavior of its REER.

In addition to developing countries, we also provide evidence on the so-called transition economies of the former Soviet Union. For the purposes of this study we call them as European less developed economies. These countries' RERs are understudied. However, it is important to investigate these countries' RERs for several reasons as discussed in detail in Alba and Park (2005). First, most of these countries are in the process entering to the euro zone and they, therefore, need an estimate of equilibrium exchange rates prior to a permanent link to the euro. If PPP does not hold well for these countries, then using PPP rates as an equilibrium exchange rate measure, as typically suggested in the literature, may not yield an appropriate exchange rate between these new EU members and the euro. Second, it is argued that testing PPP for EU candidate economies has implications for testing income convergence between these economies and their EU partners. Because PPP is generally used in measuring and hence comparing income across countries, the comparison may not be accurate if PPP fails to hold. Alba and Park (2005) consider these issues empirically by providing evidence about the validity of PPP for Turkey. Hence, our study extends their study to other EU candidate economies, as well as the lagging transition economies that are likely to apply for EU membership in the near future.

We apply the KSS tests to REERs of 88 developing economies, which consist of 24 Asian, 18 African, 25 European, and 21 Latin American less developed countries (LDCs). Like Alba and Park (2003), our sample focuses on the post-Breton Woods floating period. We employ monthly data which starts around 1980s for most of the countries, except the European LDCs. The sample period for these countries starts in early 1990s. The very early years of 1990 are

eliminated in estimations because of the erratic changes in RERs due to reforms initiated at the same time. To this end, we review and outline the KSS test for non-linear stationarity in Section II. Section III reports the results that support PPP in 50% of the countries in our sample. Finally, section IV concludes.

II. Methodology [6]

In identifying the order of integration of a time-series variable, the ADF test is perhaps the most common test, in which the null is non-stationarity of a variable against an alternative of stationarity. Recently, KSS (2003) expand the standard ADF test by keeping the null hypothesis as nonstationarity in a time series variable against the alternative of a nonlinear but globally stationary process. They demonstrate that the new test could be based on the following exponential smooth transition autoregressive (ESTAR) specification:

$$\Delta y_t = \gamma y_{t-1}[1 - \exp(-\theta y_{t-1}^2)] + \varepsilon_t, \qquad \theta \geq 0 \qquad (1)$$

where y_t is the de-meaned or de-trended series of interest, ε_t is an i.i.d. error with zero mean and constant variance, and $[1 - \exp(-\theta y_{t-d}^2)]$ is the exponential transition function adopted in the test to present the nonlinear adjustment. The null hypothesis of a unit root in y_t (i.e., $\Delta y_t = \varepsilon_t$) implies that $\theta = 0$ (thus $[1 - \exp(-\theta y_{t-d}^2)] = 0$). If θ is positive, it effectively determines the speed of mean reversion.

The KSS test hence directly focuses on the θ parameter by testing the null hypothesis of nonstationarity H_0: $\theta = 0$ against the mean-reverting nonlinear alternative hypothesis H_1: $\theta > 0$.

[6] This section draws on Bahmani-Oskooee, Kutan and Zhou (2006) who apply the KSS methodology to 23 OECD countries.

Because γ in (1) is not identified under the null, it is not feasible to directly test the null hypothesis. KSS thus reparameterize (1) by computing a first-order Taylor series approximation to specification (1) to obtain the auxiliary regression specified by (2) below:

$$\Delta y_t = \delta y_{t-1}^3 + \text{error} \qquad (2)$$

For a more general case where the errors in (2) are serially correlated, regression (2) is extended to

$$\Delta y_t = \sum_{j=1}^{p} \rho_j \Delta y_{t-j} + \delta y_{t-1}^3 + \text{error} \qquad (3)$$

with the p augmentations in order to correct for serially correlated errors. The null hypothesis to be tested with either (2) or (3) is H_0: $\delta = 0$ against the alternative of H_1: $\delta < 0$. KSS show that the t-statistic for $\delta = 0$ against $\delta < 0$, i.e., t_{NL}, does not have an asymptotic standard normal distribution and they tabulate the asymptotic critical values of the t_{NL} statistics via stochastic simulations.

We estimate the t_{NL} statistics with both regressions (2) and (3) and refer to them as t_{NL11} and t_{NL12}, respectively, for de-meaned data, and t_{NL21} and t_{NL22}, respectively, for de-trended data. The de-meaned or de-trended data are obtained by first regressing each series on a constant or on both a constant and a time trend, respectively, and then saving the residuals. The conventional ADF test statistics are also estimated, denoted as t_{ADF1} for the model with a constant only, and t_{ADF2} for the model with a constant and a time trend.

Following the suggestion of KSS (2003, p. 365), the number of augmentations p for either the ADF tests or the KSS tests is selected based on significance testing procedure in Ng

and Perron (1995). The maximum number of *p* was set to be 24 mostly because of the data being monthly, and insignificant augmentation terms were excluded.

III. Data, Sample Period and the Empirical Results

The tests are applied to the real effective exchange rates of 24 Asian, 18 African, 25 European, and 21 Latin American less developed countries (LDCs). Monthly data of the REERs of African and Latin American LDCs (except Mexico) and 5 European LDCs (Armenia, Cyprus, Macedonia, Malta, and Moldova) are collected from the International Monetary Fund (IMF)'s *International Financial Statistics* online. Those of Mexico and Turkey are from the *OECD Economic Indicators*. For the other 20 European countries and 24 Asian LDCs, the data of their REERs are obtained from the Information Notice System (INS) of the IMF. The sample period for each country is reported in tables along with the test results. Because the available data for most of countries begin around 1980, we start our sample from 1980. For some countries whose sample periods start later than 1980, this is either due to the data availability or because of the exclusion of the periods existing large breaks in their REERs during the 1980s or the earlier 90s. The ending month of the samples is August 2005 for most of the countries and is July 2003 or October 2003 for some countries when their samples have some missing observations in 2003-2004.

We report the results of the KSS test along with the standard ADF statistic for 24 Asian LDCs in Table 1. Tables 2 - 4 report the results for 18 African, 25 European, and 21 Latin American LDCs, respectively.

Tables 1-4 go about here

As indicated before, six statistics are reported. The test statistic of the standard ADF that only includes a constant is denoted by t_{ADF1}. Two tests outlined by (2) and (3) are applied to de-meaned data. The KSS test with no augmented terms that is based on (2) is denoted by t_{NL11} and the one with augmented terms that is based on (3) is denoted by t_{NL12}. The comparable statistic with trend in the ADF is t_{ADF2} and the two KSS statistics without and with augmentation for de-trended data are t_{NL21} and t_{NL22} respectively.

The test statistics in four tables show the evidence suggesting that about half of the LDC's REERs can be characterized as a stationary or trend stationary process. The null hypothesis of nonstationary REER is rejected by the ADF and/or KSS tests for 44 out of 88 economies in our study.

In all four tables, the results show that the KSS tests reject the null of nonstationarity more often than the standard ADF tests. The test statistics in Table 1 indicate that the ADF tests reject the null for only five while the KSS tests reject the null for 12 out of 24 Asian LDCs at the 10% level of significance. For the REERs of 18 African, 25 European, and 21 Latin American LDCs, the results of the KSS tests in tables 2 - 4 reject the nonstationarity for 8, 13, and 8 of them, respectively. Comparable figures for these countries based on the ADF tests are 3, 6, and 5 cases, respectively. Totally, the ADF and KSS tests reject the null for 19 and 41 out of 88 cases, respectively. In other words, the KSS tests are able to reject the unit-root null in about twice the number of cases than the ADF tests.

Does the membership of a country in a trade association have some impact on the time series behavior of its REER? If we just look at the test results of Asian LDCs, the answer might be in the affirmative. The nonstationarity of REER is rejected for seven out of nine members of the Association of Southeast Asian Nations (ASEAN), but only for 5 out of 15 other Asian

economies, implying that the REERs of the countries in a trade association are more likely to be stationary. However, the results of African, European, and Latin American LDCs may suggest the opposite: Belonging to a trade bloc does not seem to make a notable difference for the behavior of a country's REER. There is evidence for the stationarity of REER for only seven out of 15 African LDCs who are the members of either the Southern African Customs Union (SACU) or the Common Market for Eastern and Southern Africa (COMESA) or the Economic Community of Central African States (ECCAS) or the Economic Community of West African States (ECOWAS), but for two of the three remaining African LDCs in our sample who are not the members of any of these regional trade blocs. For ten new EU entrants, the null of a unit root in their REERs is rejected for only three of them. Yet, the same null is rejected for ten of the other 15 European LDCs in our study. Among 21 Latin American LDCs in our sample, the null hypothesis is rejected for Paraguay and Uruguay (two MERCOSUR members), Mexico (a NAFTA member), and Chile (who signed free-trade agreements with each of the NAFTA countries), but only for five out of 15 countries in either the Andean Community or the Caribbean Community or in the Central American Common Market.

IV. Summary and Conclusions

In an effort to coordinate their macro policies, especially to stabilize prices, most developing countries try to manage their nominal exchange rate. If these policies are to be successful, relative prices and the nominal exchange rate should converge in the long run. One implication of the convergence of relative prices and the nominal exchange rate is that the RER should be mean reverting or stationary. If they are, then the well-known theory of purchasing power parity is said to hold.

Since introduction of unit-root testing procedure many studies have tested the stationarity or mean-reverting properties of RERs by using ADF test in which the null of non-stationarity or unit root is tested against an alternative hypothesis of linear stationary. Not much support for PPP is produced by the standard ADF test. However, when the new test which incorporates non-linearity in the mean reverting properties of the real exchange rate into the testing procedure is employed, PPP is validated by most authors, though for industrial countries.

The main purpose of this paper is to test PPP by using the standard ADF as well as the KSS test (which could be considered as a new version of the ADF test) that assumes the alternative hypothesis to be non-linear stationarity. Our study differs from previous research in that we concentrate on the experience of as many developing countries as possible. Furthermore, rather than using the real bilateral exchange rate between one country and her major trading partner, we use *real effective exchange rate* which is a more comprehensive measure of movement in overall value of a country's currency.

There are 24 countries from Asia, 18 from Africa, 25 from Europe, and 21 from Latin America for a total of 88 less developed countries in the sample for which monthly real effective exchange rates were available. The results could be best summarized by saying that while the standard or linear version of the ADF test supports PPP in 19 countries, the non-linear version of the ADF test supports PPP in 41 countries, implying that in almost 50% of developing countries the real effective exchange rates revert to their mean following a non-linear path. We also find that being a member of trading block does not seem to be an important factor for PPP to hold. As shown in Alba and Park (2003), other country characteristics, such as openness and high inflation rates, tend to account better for PPP to hold. Finally, the results for the European LDCs indicate that PPP tends to hold for the majority of the countries, indicating that PPP may be used

as a yardstick to provide an estimate of the level of equilibrium exchange rate for entering the eurozone and for successfully comparing income convergence across involved countries.

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Table 1: Unit root test results for Asian LDCs

Country	Sample period	t_{ADF1}	t_{NL11}	t_{NL12}	t_{ADF2}	t_{NL21}	t_{NL22}
Bangladesh	1980:1-2005:8	-1.32	-1.37	-1.39	-2.51	-1.92	-2.07
Cambodia	1992:1-2005:8	-4.21***	-5.73***	-4.90***	-4.27***	-2.46	-2.80
China	1980:1-2005:8	-2.53	-2.59	-1.41	-1.81	-1.47	-2.64
Fiji	1980:1-2005:8	-1.77	-0.90	-1.01	-1.62	-0.99	-1.60
Hong Kong, China	1980:1-2005:8	-1.26	-1.17	-1.88	-1.05	-1.56	-1.61
India	1980:1-2005:8	-1.57	-1.44	-1.27	-0.85	-0.65	-1.96
Indonesia	1980:1-2005:8	-2.30	-2.94**	-3.08**	-1.69	-3.04	-3.61**
Korea	1980:1-2005:8	-2.54	-2.78*	-4.44***	-2.66	-2.40	-4.16***
Lao	1988:1-2005:8	-2.45	-3.15**	-3.25**	-2.47	-3.06	-3.54**
Malaysia	1980:1-2005:8	-1.32	-0.93	-1.41	-2.61	-1.76	-2.62
Maldives	1992:1-2005:8	-1.52	-3.29**	-1.91	-1.13	-3.33*	-1.97
Myanmar	1980:1-2005:8	2.30	2.75	-1.23	0.66	-0.58	-4.28***
Nepal	1980:1-2005:8	-1.60	-1.81	-1.98	-1.47	-2.47	-2.68
Pakistan	1980:1-2005:8	-3.14**	-4.14***	-3.22**	-1.65	-2.74	-2.63
Papua New Guinea	1980:1-2005:8	-1.10	-2.22	-2.16	-3.58**	-3.60**	-4.25***
Philippines	1980:1-2005:8	-1.80	-1.67	-1.40	-2.15	-1.65	-1.48
Samoa	1980:1-2005:8	-2.93**	-2.31	-2.35	-1.35	-2.41	-2.11
Singapore	1980:1-2005:8	-2.75*	-1.25	-2.92*	-2.75	-1.20	-2.83
Solomon Islands	1980:1-2005:8	-2.18	-1.92	-1.89	-1.96	-1.90	-2.14
Sri Lanka	1980:1-2005:8	-2.56	-2.21	-2.94**	-2.65	-1.91	-2.49
Thailand	1980:1-2005:8	-1.27	-2.57	-2.80*	-2.49	-5.23***	-6.70***
Tonga	1980:1-2005:8	-1.84	-1.95	-1.76	-2.56	-2.21	-1.98
Vanuatu	1980:1-2005:8	-1.85	-2.12	-2.06	-1.43	-2.46	-2.40
Vietnam	1990:1-2005:8	-2.90**	-3.70***	-4.83***	-2.68	-3.41**	-4.69***

Notes: t_{ADF1} and t_{ADF2} are the standard ADF test statistics for the null of stationarity and the null of trend stationarity, respectively, of the variable in the study. t_{NL11} and t_{NL12} are the KSS test statistics for the de-meaned data using the models without and with augmentations, respectively. t_{NL21} and t_{NL22} are the KSS test statistics for the de-trended data using the models without and with augmentations, respectively. The 10%, 5%, and 1% asymptotic critical values for t_{ADF1} are -2.57, -2.86, and -3.43, respectively, and those for t_{ADF2} are -3.12, -3.41, and -3.96, respectively. The 10%, 5%, and 1% asymptotic critical values for t_{NL11} and t_{NL12} are -2.66, -2.93, and -3.48, respectively, and those for t_{NL21} and t_{NL22} are -3.13, -3.40, and -3.93, respectively, taken from Kapetanios et al. (2003, p. 364). *, ** and *** denote rejection of the null hypothesis at the 10%, 5% and 1% significance levels, respectively.

Table 2: Unit root test results for African LDCs

Country	Sample period	t_{ADF1}	t_{NL11}	t_{NL12}	t_{ADF2}	t_{NL21}	t_{NL22}
Algeria	1980:1-2005:8	-1.34	-0.72	-1.85	-2.41	-1.12	-3.64**
Burundi	1980:1-2005:8	-1.50	-1.45	-1.88	-2.43	-2.83	-3.42**
Cameroon	1980:1-2003:7	-1.39	-1.90	-1.40	-2.16	-2.51	-1.92
Central African Rep.	1980:1-2003:10	-1.35	-1.94	-1.64	-2.78	-2.56	-2.47
Côte d'Ivoire	1980:1-2003:7	-1.94	-2.13	-2.18	-2.10	-2.76	-2.91
Equatorial Guinea	1985:1-2005:8	-1.20	-2.41	-0.57	-2.00	-1.77	0.10
Gabon	1980:1-2005:8	-1.04	-1.49	-1.23	-1.87	-3.22*	-2.99
Gambia	1986:1-2005:8	0.35	0.26	-0.32	-1.10	-1.07	-1.71
Ghana	1986:1-2005:8	-1.77	-1.35	-1.98	-2.43	-1.33	-1.97
Lesotho	1980:1-2003:7	-0.91	-1.50	-1.96	-2.06	-1.92	-2.62
Malawi	1980:1-2003:7	-1.34	-1.76	-1.30	-3.57**	-2.26	-1.79
Morocco	1980:1-2005:8	-2.90**	-3.14*	-2.41	-2.84	-2.30	-2.18
Sierra Leone	1987:1-2005:8	-2.15	-4.51***	-3.71***	-2.22	-4.19***	-3.34*
South Africa	1980:1-2005:8	-1.79	-1.27	-1.57	-2.14	-2.86	-3.64**
Togo	1980:1-2003:10	-1.94	-2.95**	-2.13	-2.72	-2.91	-1.88
Tunisia	1980:1-2005:8	-2.09	-1.81	-1.80	-1.92	-1.74	-2.70
Uganda	1990:1-2005:8	-0.82	-1.55	-1.46	-2.46	-2.74	-2.85
Zambia	1980:1-2005:8	-3.05**	-4.15***	-4.32***	-2.91	-3.73**	-3.82**

See notes to Table 1

Table 3: Unit root test results for European LDCs

Country	Sample period	t_{ADF1}	t_{NL11}	t_{NL12}	t_{ADF2}	t_{NL21}	t_{NL22}
Albania	1992:1-2005:8	-1.07	-1.14	-1.57	-2.51	-2.50	-3.93***
Armenia	1994:1-2005:8	-0.82	-2.91*	-0.84	-1.75	-3.11	-0.97
Azerbaijan	1994:1-2005:8	-0.95	-1.67	-2.44	-2.14	-1.81	-2.44
Belarus	1994:1-2005:8	-1.22	-1.93	-1.73	-1.98	-1.81	-1.25
Bulgaria	1992:1-2005:8	-0.80	-2.69*	-2.70*	-3.71**	-4.10***	-4.34***
Croatia	1992:1-2005:8	-2.18	-6.64***	-4.95***	-3.35*	-6.59***	-6.00***
Cyprus	1980:1-2005:8	-1.95	-2.51	-2.46	-1.44	-1.25	-1.49
Czech Republic	1992:1-2005:8	-1.10	-1.14	-1.27	-2.92	3.23*	-3.27*
Estonia	1992:6-2005:8	-2.45	-1.82	-2.00	-2.30	-1.03	-1.37
Hungary	1992:1-2005:8	0.77	0.46	0.05	-2.19	-2.21	-2.50
Kyrgyz Republic	1994:1-2005:8	-2.40	-1.65	-1.94	-1.79	-1.90	-2.01
Latvia	1992:6-2005:8	-1.26	-0.53	-1.03	-1.24	-0.02	-1.01
Lithuania	1994:1-2005:8	-2.17	-1.70	-1.52	-1.06	-0.35	-0.99
Macedonia	1992:6-2005:8	-1.71	-1.62	-2.18	-2.17	-2.50	-3.51**
Malta	1980:1-2005:8	-2.42	-1.72	-2.38	-1.40	-2.01	-2.79
Moldova	1994:1-2005:8	-2.45	-4.44***	-5.84***	-2.40	-4.45***	-5.89***
Poland	1992:1-2005:8	-1.79	-1.70	-2.13	-2.32	-2.07	-2.53
Romania	1992:1-2005:8	-0.75	0.32	-0.89	-3.50**	-2.58	-3.89**
Russia	1994:1-2005:8	-1.95	-1.11	-1.85	-1.93	-1.33	-1.96
Slovak Republic	1992:1-2005:8	-1.08	-0.50	-3.25**	-3.24*	-0.88	-3.82**
Slovenia	1992:6-2005:8	-1.49	-4.41***	-3.44**	-1.98	-3.23*	-2.29
Tajikistan	1992:1-2005:8	-1.55	-2.60	-2.52	-1.10	-2.18	-2.17
Turkey	1980:1-2005:8	-2.01	-2.27	-2.74*	-1.81	-1.77	-2.20
Ukraine	1992:1-2005:8	-2.79*	-2.56	-4.75***	-2.86	-2.56	-4.60***
Uzbekistan	1994:1-2005:8	-1.44	-2.96**	-2.85*	-2.25	-2.99	-2.85

See notes to Table 1

Table 4: Unit root test results for Latin American LDCs

Country	Sample period	t_{ADF1}	t_{NL11}	t_{NL12}	t_{ADF2}	t_{NL21}	t_{NL22}
Antigua and Barbuda	1980:1-2005:8	-2.01	-1.32	-1.70	-2.79	-1.88	-2.41
Belize	1980:1-2005:8	-2.40	-0.95	-2.19	-3.54**	-1.10	-2.35
Bolivia	1986:1-2005:8	-1.50	-0.56	-1.07	-1.75	-2.36	-2.89
Chile	1980:1-2005:8	-4.64***	-3.66***	-3.96***	-3.67**	-2.79	-3.22*
Colombia	1980:1-2005:8	-2.28	-1.23	-1.51	-1.97	-0.90	-1.59
Costa Rica	1981:1-2005:8	-2.75*	-2.05	-2.94**	-2.77	-1.96	-2.77
Dominica	1980:1-2005:8	-2.33	-1.98	-2.32	-2.73	-2.03	-2.39
Dominican Republic	1980:1-2005:8	-2.39	-2.46	-2.20	-2.17	-1.80	-1.93
Ecuador	1980:1-2005:8	-2.86**	-3.39***	-3.03**	-2.14	-2.65	-2.36
Grenada	1980:1-2003:7	-1.46	-1.58	-1.73	-1.73	-1.67	-1.83
Guyana	1990:1-2005:8	-2.18	-2.10	-1.87	-1.54	-1.32	-1.61
Mexico	1980:1-2005:8	-3.61***	-3.29**	-4.03***	-5.79***	-5.51***	-6.65***
Netherlands Antilles	1980:1-2003:7	-2.21	-1.10	-1.36	-2.86	-1.65	-2.23
Nicaragua	1992:1-2005:8	-2.28	-1.17	-1.98	-2.30	-1.47	-2.38
Paraguay	1980:1-2003:7	-2.29	-2.68*	-2.07	-1.95	-1.75	-0.23
St. Kitts and Nevis	1980:1-2005:8	-1.82	-2.15	-3.17**	-1.90	-2.32	-3.39*
St. Lucia	1980:1-2003:7	-1.72	-2.42	-2.40	-1.73	-2.41	-2.38
St. Vincent & Grens.	1980:1-2005:8	-2.02	-2.56	-2.99**	-2.19	-2.67	-3.12
Trinidad and Tobago	1986:1-2005:8	-1.94	-2.06	-1.84	-2.06	-1.84	-1.57
Uruguay	1983:1-2003:7	-1.46	-1.28	-1.89	-1.19	0.03	-3.14*
Venezuela	1980:1-2003:7	-1.82	-1.74	-1.71	-1.79	-1.64	-1.60

See notes to Table 1