E C O N O M I C S B U L L E T I N

Testing PPP for Central American real exchange rates. Evidence from new panel data stationary tests with structural breaks

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Abstract

The new panel data stationary test with multiple structural breaks developed by Carrion-i-Silvestre, Del Barrio-Castro and Lopez-Bazo (2005) is used along with standard stationary tests to study the long-run PPP hypothesis in a set of six Central American countries for the period 1976:1-2006:4. Contrary to standard tests, this new procedure provides strong support for PPP.

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1. Introduction

Testing for long-run Purchasing Power Parity (PPP) remains a major problem in international economics (Sarno and Taylor, 2002). The PPP hypothesis considers a proportional relation between the nominal exchange rate and the relative price ratio, which implies that the real exchange rate (RER) is constant over time. So, the most common way to test for PPP consists in investigating unit roots in RERs. If the unit root can be rejected in favour of level stationarity, then deviations from parity are temporary (RER is a mean reverting process) and PPP is said to hold in the long run.

Empirical literature on PPP has therefore focused on the credibility of the unit root finding and on why deviations from PPP exist. However, despite extensive researches in analysing PPP we are still unable to draw homogenous conclusions (Taylor and Taylor, 2004). This lack of consensus has been attributed to the low power of these tests. As a result, the recent literature, mainly focused on industrial and large emerging economies, has moved on in two new directions. While some researchers have turned to panel unit root tests others have opted for nonlinear unit root tests (Taylor, 2006; Bahmani-Oskooee *et al.*, 2007).

However, few studies have been conducted using data from small developing countries and, in particular, from Central America (Holmes, 2001; Cerrato and Sarantis, 2003; Hoarau, 2007). Moreover, no consensus has been reached at time. This outcome is very surprising in the extent that this area is likely to be largely commercially and financially integrated (Rodlauer and Schipke, 2005).

So, this paper aims at pursuing investigations about long-run PPP hypothesis for these countries but in an original way. We apply a new panel data stationary testing procedure suggested by Carrion-i-Silvestre, Del Barrio-Castro and Lopez-Bazo (hereafter, CDL) (2005), which allows for the structural changes to shift the mean and/or the trend of the individual time series, to bilateral RER data[1] for six Central American Economies (Costa-Rica, El Salvador, Guatemala, Honduras, Mexico and Dominican Republic). Indeed, no considering the presence of structural breaks in the series can deteriorate the results obtained from standard procedures (Huang *et al.*, 1997). Otherwise, no study has already used this methodology for assessing the validity of PPP at date. We use quarterly data from 1976:1 through 2006:4.

Then, in what follows, we briefly explain the CDL test in Section 2 and report the results in Section 3. Section 4 concludes.

2. The method

This article employs a new panel procedure based on CDL (2005) to address the multiple structural breaks problem. Following the test of Hadri (2000), this new test still considers the null hypothesis of stationarity for all cross-sections but the influence of structural breaks is taken into account in a very convenient way. The procedure is general enough to allow the following characteristics: *(i)* the structural breaks can have different effects on each individual time series, *(ii)* they can be located at different dates and *(iii)* individuals can have different number of structural breaks.

Firstly, consider the following regressions which encompass $i = 1,...,N$ individuals and $t = 1,...,T$ time periods:

[1] The US dollar is used as numeraire currency. The series are obtained from ERS-USDA database available online at http://www.ers.usda.gov/data/macroeconomics/. Otherwise, our focus in this paper is the real bilateral exchange rates rather than the effective ones in the extent that the pattern of the Central America countries' foreign trade is strongly dominated by USA.

(1) $y_{i,t} = \alpha_{i,t} + \beta_i t + \varepsilon_{i,t}$

and

(2) $\alpha_{i,t} = \sum_{k=1}^{m_i} \theta_{i,k} D(T_{b,k}^i)_t + \sum_{k=1}^{m_i} \gamma_{i,k} DU_{i,k,t} + \alpha_{i,t-1} + \upsilon_{i,t}$

where $\upsilon_{i,t}$ ~i.i.d.$(0, \sigma_{\upsilon,i}^2)$ and $\alpha_{i,0} = \alpha_i$, a constant. The dummy variables $D(T_{b,k}^i)_t$ and $DU_{i,k,t}$ are defined as $D(T_{b,k}^i)_t = 1$ for $t = T_{b,k}^i + 1$ and 0 elsewhere, and $DU_{i,k,t} = 1$ for $t > T_{b,k}^i$ and 0 elsewhere, with $T_{b,k}^i$ giving the kth date of the break for the ith individual, $k = 1,...,m_i$, $m_i \geq 1$. Moreover, note that the stochastic processes $\{\varepsilon_{i,t}\}$ and $\{\upsilon_{i,t}\}$ are taken to be mutually independent across the two dimensions of the panel data set. So, if we state the condition $\sigma_{\upsilon,i}^2 = 0$ for all $i = 1,...N$, *i.e.* the null hypothesis of a stationary panel, substituting (2) in (1) results in:

(3) $y_{i,t} = \alpha_i + \sum_{k=1}^{m_i} \theta_{i,k} DU_{i,k,t} + \beta_i t + \sum_{k=1}^{m_i} \gamma_{i,t} DT_{i,k,t}^* + \varepsilon_{i,t}$

with the dummy variable $DT_{i,k,t}^* = t - T_{b,k}^i$ for $t > T_{b,k}^i$ and 0 elsewhere, $k = 1,...,m_i$, $m_i \geq 1$.

Then, the test of the null hypothesis relies on a test statistic which is simply the average of the univariate stationary tests in KPSS. The general expression for the test statistic is:

(4) $LM(\lambda) = N^{-1} \sum_{i=1}^{N} \left(\hat{\omega}^{-2} T^{-2} \sum_{t=1}^{T} \hat{S}_{i,t}^2 \right)$ for the homogeneous case

(5) $LM(\lambda) = N^{-1} \sum_{i=1}^{N} \left(\hat{\omega}_i^{-2} T^{-2} \sum_{t=1}^{T} \hat{S}_{i,t}^2 \right)$ for the heterogeneous case

where $\hat{S}_{i,t} = \sum_{j=1}^{t} \hat{\varepsilon}_{i,j}$ denotes the partial sum process that is obtained using the estimated OLS residuals of (3), with $\hat{\omega}_i^2$ being a consistent estimate of the long-run variance of $\varepsilon_{i,t}$, $\omega_i^2 = \lim_{T \to \infty} T^{-1} E(S_{i,T}^2), i = 1,...,N$, and $\hat{\omega}^2 = N^{-1} \sum_{i=1}^{N} \hat{\omega}_i^2$. Note that λ is used in (4) and (5) to denote the dependence of the test on the dates of break. For each individual i, it is defined as the vector $\lambda_i = (\lambda_{i,1},...,\lambda_{i,m_i})' = (T_{b,1}^i / T,...,T_{b,m_i}^i / T)$ which indicates the relative positions of the dates of the breaks on the entire time period T. Finally, by defining $\bar{\xi} = N^{-1} \sum_{i=1}^{N} \xi_i$ and $\bar{\zeta}^2 = N^{-1} \sum_{i=1}^{N} \zeta_i^2$, with ξ_i and ζ_i^2 the individual mean and variance of $\eta_i(\lambda_i)$, respectively, the

test statistic for the null hypothesis of a stationary panel with multiple shifts is under mild assumptions[2]:

$$(6) \qquad Z(\lambda) = \frac{\sqrt{N}\,(LM(\lambda) - \bar{\xi})}{\bar{\zeta}} \xrightarrow{d} N(0,1)$$

At this stage, the break fraction vector has been considered as given. However, this latter is usually unknown and must therefore be estimated. Consequently, computing the test statistic requires to detect the breaks in each one of the individual time series as a preliminary step. In this regard, and as suggested in CDL (2005), we use a grid search procedure developed along the lines of Bai and Perron (1998)[3].

3. The results

We report the results of the CDL test along with the KPSS and the Hadri tests in Table 1 for the Central American countries. Note that all tests consider a specification with a constant but without a time trend because time trend in RERs is not consistent with the long-run PPP. Moreover, both Bartlett and Quadratic Spectral kernels are used for estimating the long-run variance.

Table 1. Stationary tests results for Central American countries

Individual series	**KPSS test**		**Structural breaks detection**	
	Bartlett	**Quadratic Spectral**	**Number**	**Dates**
Costa-Rica	0.625 (9)**	0.659 (7.01)**	1	1980:4
El Salvador	1.206 (9)**	1.294 (7.16)**	3	1982:1; 1988:1; 1994:4
Guatemala	0.618 (9)**	0.666 (7.11)**	3	1986:2; 1994:1; 2001:2
Honduras	0.752 (9)**	0.813 (7.19)**	3	1982:4; 1990:1; 1998:1
Mexico	0.268 (8)	0.273 (6.32)	2	1981:4; 1990:1
Dominican Republic	0.721 (9)**	0.773 (7.08)**	2	1984:4; 1989:2
The whole panel	**Hadri test (without structural breaks)**		**CDL test (with structural breaks)**	
	Bartlett [Prob.]	**Quadratic Spectral [Prob.]**	**Bartlett [Prob.]**	**Quadratic Spectral [Prob.]**
Homogeneous Z-stat	8.793 [0.000]**	9.495 [0.000]**	0.881 [0.189]	0.896 [0.185]
Heterogeneous Z-stat	8.738 [0.000]**	9.522 [0.000]**	0.041 [0.484]	0.062 [0.475]

Notes: (*) (**) indicate rejection of the null hypothesis of stationarity at the 10% and 5% significance level, respectively. The long-run variance is estimated with automatic spectral window bandwidth selection (figures in parentheses) as in Newey-West (1994) for the KPSS and Hadri tests, and as Andrews and Monahan (1992) for the CDL test.

Concentrating on the KPSS test, we gather from Table 1 that the null of no unit root is rejected in favour of nonstationarity of the RER in five (Costa-Rica, El Salvador, Guatemala, Honduras, Dominican Republic) out of six countries, so giving poor support for PPP. The evidence of mean-reversion is found only for Mexico. However, as usually noted, the low power of individual KPSS test in short samples can result in rejecting too easily the null

[2] The sign $\xrightarrow{d}$ denotes weak convergence in distribution. CDL (2005) demonstrate that the test gives good performance in finite samples by Monte Carlo simulations.

[3] The complete results for the Bai-Perron estimates for each country are available upon request from the author. Only the number and the dates of the breaks are reported in Table 1. The optimal number of breaks has been estimated using the BIC information criteria allowing for a maximum of five structural breaks.

hypothesis of stationarity. One way to handle this problem is to apply the standard panel data stationary test of Hadri. But, this latter (we use both the homogeneous and the heterogeneous tests), which considers the null of no unit root in any of the series in the panel, corroborate the univariate KPSS test so that stationarity for the whole panel is strongly rejected whatever the version retained and the kernel method used. Thus, from the standard stationary tests, we can conclude that long-run PPP does not hold for our sample.

Nevertheless, as noted earlier, no considering the presence of structural breaks can given misleading conclusions about the behaviour of RERs and then about PPP. Besides, the CDL test shows that the null hypothesis of panel stationarity cannot be rejected at the 5% level of significance for both the Bartlett and Quadratic Spectral kernel regardless of the assumption concerning the heterogeneity in the long-run variance estimate. So, in accordance with the CDL test, taking into account the presence of structural breaks leads to the acceptance of long-run PPP for all countries in the panel[4]. Note that if the RER is stationary but around a mean which is subject to occasional structural changes as in our case, there is reversion to a changing mean. So, the hypothesis validated here is not really the conventional PPP but the so-called Quasi PPP of Hegwood and Papell (1998).

4. Conclusions

In this article, we implemented the new panel data stationary test of CDL (2005) to study whether or not there is support for long-run PPP in a set of six Central American countries over the period 1976:1-2006:4. This method has the crucial advantage to allow for the presence of multiple structural breaks in each individual time series. Finally, it leads to the conclusion that PPP (more exactly Quasi PPP) holds in the long-run for our panel, *i.e.* the RERs are mean-reverting but around a changing mean.

All in all, mean-reversion has two major implications for economic policy as long as Central American economies are concerned. Firstly, the equilibrium RERs and misalignment indicators of these countries can be obtained from simple PPP calculations. Secondly, since their nominal exchange rates appear to move closely with the US dollar, the validity of PPP hypothesis means the existence of a price convergence process in Central America.

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[4] Cross-sectional dependence is expected in panels on RERs if a common currency such as the US dollar is used as a base. And, no accounting for it is likely to falsely reject a unit root (O'Connell, 1998). So, following Maddala and Wu (1999), we have computed the bootstrap distribution (with 2,000 replications) in order to take into account this problem. But, given that the results are not qualitatively modified, we have not reported them in this article.

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