E c o n o m i c s B u l l e t i n

Testing for PPP in Australia: Evidence from unit root test against nonlinear trend stationarity alternatives

Juan Carlos Cuestas
Nottingham Trent University

Paulo José Regis
University of Nottingham

Abstract

This paper tests for the empirical fulfilment of PPP in Australia (1977-2004). Previous research focuses on the presence of structural breaks and fails to find any support for PPP (Darne and Hoarau, 2008, Henry and Olekalns, 2002). In contrast, we find that the real exchange rate is stationary once we account for a more general specification of the nonlinear deterministic components based on a Chebishev polynomials approximation.

Juan Carlos Cuestas gratefully acknowledges the financial support from the CICYT and FEDER project SEJ2005-01163, the Bancaja project P1.1B2005-03 and the Generalitat Valenciana Complementary Action ACOMP07/102. The authors gratefully acknowledge Nik Masters and David Harvey for their useful comments. Juan Carlos Cuestas is a member of the INTECO research group. The usual disclaimer applies.
Citation: Cuestas, Juan Carlos and Paulo José Regis, (2008) "Testing for PPP in Australia: Evidence from unit root test against nonlinear trend stationarity alternatives." *Economics Bulletin,* Vol. 3, No. 27 pp. 1-8
Submitted: February 16, 2008. **Accepted:** May 16, 2008.
URL: http://economicsbulletin.vanderbilt.edu/2008/volume3/EB-08C20010A.pdf

1 Introduction

The empirical fulfilment of Purchasing Power Parity (PPP) has probably been one of the most controversial topics in international economics in recent decades. Many authors have contributed to the literature, using different countries, time periods and econometric techniques. However, the results have been on many occasions contradictory[1].

The importance of the analysis of PPP is, at least, twofold. First, many macroeconomic momentary models are based on the PPP assumption. Second, the real exchange rate can be considered a measure of economic integration and external competitiveness (Wei and Parsley, 1995) and its understanding can be helpful for exchange rate policy design.

In short, the absolute version of the PPP theory establishes that the real exchange rate (RER) between two currencies must be equal to 1 and, therefore, both currencies must have a similar purchasing power. However, rejection of the absolute PPP hypothesis does not necessarily imply that national prices are exclusively explained by idiosyncratic factors; prices may still respond to proportional instead of identical components, implying that the RER may be constant but different from 1. This second interpretation is the relative version of the PPP theory.

It is well known within the literature that if PPP holds, it only does in the long run. This long run relation implies that shocks affecting the currencies have only effects on the dynamics; therefore, one can only accept the PPP hypothesis when the RER is a stationary process. Testing for the empirical validity of PPP is closely related to testing for unit roots in the RER (Meese and Rogoff 1988; Mark, 1990; Ardeni and Lubian, 1991; Huizinga, 1987, among others). However, it has been argued that traditional unit root tests might suffer from power problems when the deterministic components are not properly specified (Perron and Phillips, 1987; and West, 1988, among others). Thus, the existence of structural changes in the series may bias the results of these unit root tests in favour of the null hypothesis.

Dealing with this particular case of nonlinearity, an increasing number of authors have applied unit root tests with structural changes, finding in general results more favourable to the stationarity of the RER. In such a case, what we have is the so-called Quasi-PPP (Hegwood and Papell, 1998). Following this approach, a recent paper by Darné and Hoarau (2008) analyses the empirical fulfilment of the PPP theory in Australia, applying the Perron and Rodríguez (2003) unit root tests with structural changes. Although they obtain a structural change in 1985, coinciding with the currency crisis suffered by the Australian dollar, their results point to the rejection of the PPP hypothesis. Likewise, Henry and Olekalns (2002) also reject the PPP hypothesis for the Autralian RER, using the Zivot and Andrews (1992) and Perron (1997) unit root tests with breaks.

Bearing in mind that an incorrect specification of the deterministic components may bias the results towards the integrated process hypothesis, in the present paper we apply a unit root test which approximates the deterministic components with a more general specification for structural changes, i.e. a nonlinear deterministic trend (Bierens, 1997). The existence of a stationary RER around a nonlinear trend can be understood as a time varying or nonconstant equilibrium exchange rate. That is, variations in the fundamentals that determine the RER should give rise to a different RER equilibrium value. Sometimes, the nature of the changes in the fundamentals are not properly identified as a broken trend and a more general approximation is required. This can occur when dealing with aggregate data (Granger and Teräsvirta, 1993), since different agents do not normally take economic or portfolio decisions at the same time.

An early contribution to this approach is Lothian and Taylor (2000), who propose that the RER deterministic trend is better approximated by a cubic function. Moreover, in recent years, the literature on the analysis of the order of integration of the RER has started to pay special attention to the possibility of a stationary RER around a nonlinear deterministic trend. For instance, Sollis (2005), Assaf (2006), Cushman (2008), Camarero et al. (2008) and Cuestas (2008) find in general that the real exchange rate may be a nonlinear trend stationary process instead of a unit root and therefore evidence in favour of a more relaxed version of PPP or Quasi-PPP.

Summing up, there are two approaches to nonlinearities to support the Quasi-PPP hypothesis: some studies look for evidence in favour of structural changes while others explore the existence of a nonlinear deterministic trend. However, sometimes it is difficult to make a clear distinction between them. Other times, the evidence is more clear about what explanation seems more plausible. When sudden structural breaks are preferred, a more general nonlinear trend implies a misspecified model, where the estimation of an overfitted model may yield to incorrect conclusions. On the other hand, both approaches may be complementary. If the data fits better a general nonlinear trend, structural breaks may still be useful to give an interpretation of historic events that may help in explaining the causes of the nonlinearity.

This paper aims at providing some evidence in favour of the Quasi-PPP hypothesis in Australia. First, we rely on the Darné and Hoarau (2008) findings for unit root tests with a sudden structural break. Second, the existence of a nonlinear deterministic trend is tested, applying Bierens (1997) unit root tests. This author proposes several tests for the unit root hypothesis against the alternative of nonlinear trend stationarity, where the nonlinear trend is approximated by means of Chebishev polynomials. Contrary to the previous literature, our findings point to different results: the RER in Australia appears to be a stationary process around a nonlinear deterministic trend for the analysed period.

In the next section we summarise the Bierens (1997) technique and the results of applying this technique. The last section concludes.

2 Nonlinear unit root tests and results

In this section we test for the order of integration of the real exchange rate of Australia. The data correspond to the RER computed by the Reserve Bank of Australia[2] from January 1977 to April 2004, the same time series used by Darné and Hoarau (2008).

Since time series are most usually modelled by means of linear equations, unit root tests might be biased by the presence of nonlinearities in the deterministic components. It is a standard practice to introduce structural breaks and additive outliers in order to account for this possibility in the series of the RER. The identification of structural breaks and outliers is also informative since it provides a direct interpretation of economic events. An alternative approach is to introduce a more general approximation to the nonlinear deterministic component. The approximation would also capture the structural breaks with a smoother functional form for the transition period. It is in this direction that this paper makes a contribution to the previous literature.

To test for the order of integration of the RER, we apply the unit root tests developed by Bierens (1997). This procedure accounts for the general case of a nonlinear deterministic trend when testing for unit roots, by extending the augmented Dickey-Fuller (ADF) test introducing orthogonal Chebishev polynomials. The ADF equation becomes

$$\Delta x_t = \alpha x_{t-1} + \sum_{j=1}^{p} \phi_j \Delta x_{t-j} + \theta^T P_{t,n}^{(m)} + \varepsilon_t \qquad (1)$$

where $P_{t,n}^{(m)}$ are the Chebishev polynomials of order m. The null hypothesis is formulated such that α and the last m components of θ are not significant. In this paper we apply the $\hat{t}(m)$ test, which is a t-test on the significance of the coefficient α. In addition, and in order to check the robustness of the previous results, we also apply the $\hat{A}(m) = \frac{n\hat{\alpha}}{|1-\sum_{i=1}^{p}\hat{\phi}_i|}$ test, an alternative test for the same hypothesis. The distinction between linear or nonlinear trend stationarity depends upon the side of the rejection. Whereas right side rejection (a p-value > 0.90) implies stationarity around a nonlinear deterministic trend, left side rejection (a p-value < 0.10) does not allow us to distinguish between mean stationarity or stationarity around a deterministic trend (see Table 1).

Figure 1 shows the RER series. It appears that the variable does not seems to follow a linear behaviour. Instead, a nonlinear deterministic trend would probably be a better statistical characterisation for this variable's deterministic component. Note that the estimated nonlinear trend adjusts smoothly the structural changes, instead of assuming sudden changes in the trend.

The results are displayed in Table 2. The p-values are based on Monte Carlo simulations with 5,000 replications of a Gaussian $AR(p)$ process for Δx_t. The parameters and error variances are equal to the estimated $AR(p)$ null model, where the lag length for the ADF regression p has been selected by the Akaike Information Criterion[3] ($p = 0$)

and the initial values have been taken from the actual series[4]. For comparison purposes we have also performed the ADF test. Note that with the ADF test, it is not possible to reject the null hypothesis of a unit root at conventional significance levels. However, the nonlinear unit root tests point to the rejection of the null hypothesis of a unit root in favour of the alternative of stationarity around a nonlinear trend[5], where $m = 7$.

Our results are therefore different to those obtained by Darné and Hoarau (2008). Although these authors find a structural break in the Australian RER in 1985, a nonlinear deterministic trend appears to be a better approximation for the deterministic components of the RER. In addition to this, our finding does not support the Balassa-Samuelson effect, which implies that the RER should be stationary around a constant trend. Instead, the results here reported are in favour of the Quasi-PPP interpretation.

Finally, we explore whether structural breaks can explain most of the nonlinearity. In order to test for the importance of structural breaks as the main source of the nonlinearity, we also perform the Bierens (1997) test over the variable previously transformed to account for a structural break in the intercept and trend[6]. If this structural break is important to explain the nonlinearity, we expect to reject the null hypothesis of a unit root for the transformed variable with a low Chebishev polynomial order (i.e. m close to zero). The new results[7] show that the transformed variable is stationary around a nonlinear trend for m equal to 5, which is very similar to our initial results of $m = 7$. This suggests that the sudden structural break is not able to capture the true nature of the nonlinearity. Therefore, the Chebishev polynomials appear to approximate the nonlinear deterministic component better than a single structural break.

3 Conclusion

Previous literature (Darné and Hoarau, 2008, Henry and Olekalns, 2002) test for the empirical validity of PPP in Australia applying unit root tests with structural changes. Their results point to the rejection of the PPP hypothesis. Aimed at complementing this analysis, we generalise the case of structural break to a nonlinear deterministic trend. The results point to the fact that the RER is nonlinear trend stationary, accepting the Quasi-PPP hypothesis. This suggests that it is worth considering alternative forms for approximating the deterministic trends to structural breaks in the coefficients of a linear equation when testing for the order of integration of the RER.

Notes

[1]See Taylor (2006) for a recent survey of the literature
[2]Available at http://www.rba.gov.au/Statistics/real_exchange_rate_indices.xls.
[3]The same lag length is also obtained by the Schwarz Bayesian Information Criterion.
[4]The order of p used to obtain the statistic and the p-values are the same.
[5]We have selected the order of m that yields more evidence against the null hypothesis.
[6]Preliminary examination of the data reveals the most likely structural break occurs in 1985:1
[7]Available upon request to the corresponding author.

References

Ardeni, P. G. and D. Lubian (1991): "Is there a trend reversion in purchasing power parity?", *European Economic Review*, vol. 35, pp. 1035–1055.

Assaf, A. (2006): "Nonlinear trend stationarity in real exchange rates: Evidence from nonlinear adf tests", *Annals of Economics and Finance*, vol. 2, pp. 283–294.

Bierens, H. J. (1997): "Testing the unit root with drift hypothesis against nonlinear trend stationarity, with an application to the U.S. price level and interest rate", *Journal of Econometrics*, vol. 81, pp. 29–64.

Camarero, M., J. C. Cuestas and J. Ordóñez (2008): "Nonlinear trend stationarity of real exchange rates: The case of the Mediterranean countries", *International Jounral of Banking, Accounting and Finance*, forthcoming.

Cuestas, J. C. (2008): "Purchasing power parity in Central and Eastern European countries: An analysis of unit roots and nonlinearities", *Applied Economics Letters*, forthcoming.

Cushman, D. (2008): "Real exchange rates may have nonlinear trends", *International Journal of Finance and Economics*, vol. 13, pp. 158–173.

Darné, O. and J.-F. Hoarau (2008): "The purchasing power parity in Australia: Evidence from unit root test with structural break", *Applied Economics Letters*, vol. 15, pp. 203–206.

Granger, C. W. J. and T. Teräsvirta (1993): *Modelling Nonlinear Economic Relationships*, Oxford University Press, Oxford.

Hegwood, N. D. and D. Papell (1998): "Quasi purchasing power parity", *International Journal of Finance and Economics*, vol. 3, pp. 279–289.

Huizinga, J. (1987): "An empirical investigation of the long-run behavior of real exchange rates", *Carnegie-Rochester Conference Series on Public Policy*, vol. 27, pp. 149–214.

Lothian, J. R. and M. P. Taylor (2000): "Purchasing power parity over two centuries: Stregthening the case for real exchange rate stability", *Journal of International Money and Finance*, vol. 19, pp. 759–764.

Mark, N. (1990): "Real and nominal exchange rates in the long run: An empirical investigation", *Journal of International Economics*, vol. 28, pp. 115–136.

Meese, R. A. and K. Rogoff (1988): "Was it real? the real exchange rate-interest differential relation over the modern floating-rate period", *Journal of Finance*, vol. 43, pp. 933–948.

Perron, P. (1997): "Further evidence on breaking trend functions in macroeconomic variables", *Journal of Econometrics*, vol. 80, pp. 355–385.

Perron, P. and G. Rodríguez (2003): "GLS detrending, efficient unit root tests and structural change", *Journal of Econometrics*, vol. 115, pp. 1–27.

Perron, P. and P. C. B. Phillips (1987): "Does GNP have a unit root? A reevaluation", *Economics Letters*, vol. 23, pp. 139–145.

Sollis, R. (2005): "Evidence on purchasing power parity from univariate models: the case of smooth transition trend-stationarity", *Journal of Applied Econometrics*, vol. 20, pp. 79–98.

Taylor, M. P. (2006): "Real exchange rates and Purchasing Power Parity: Mean-reversion in economic thought", *Applied Financial Economics*, vol. 16, pp. 1–17.

Wei, S.-J. and D. C. Parsley (1995): "Purchasing power disparity during the float rate period: Exchange rate volatility, trade barriers and other culprits", Working Paper 5032, NBER.

West, K. D. (1988): "Asymptotic normality when regressors have a unit root", *Econometrica*, vol. 56, pp. 1397–1418.

Zivot, E. and D. W. K. Andrews (1992): "Further evidence on the Great Crash, the oil-price shock, and the unit-root hypothesis", *Journal of Business and Economic Statistics*, vol. 10, pp. 251–270.

Table 1: Alternative hypotheses

Test	Left-side rejection	Right-side rejection
$\hat{t}(m)$	MS, LTS or NLTS	NLTS
$\hat{A}(m)$	MS, LTS or NLTS	NLTS

Note: MS= mean stationarity, LTS= linear trend stationarity, NLTS= nonlinear trend stationarity.

Table 2: Unit root test results

	$\hat{A}(m)$	$\hat{t}(m)$	$\hat{t}_{ADF}$
statistic	-15.1133	-2.7758	-1.6608
p-value	0.9950	0.9832	0.7600

Figure 1: Australian RER and nonlinear trends