A Panel Test of Purchasing Power Parity under the Null of Stationarity.

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Abstract

Purchasing Power Parity (PPP) is tested using a sample of real exchange rate data for twelve European countries. Acknowledging that Augmented Dickey Fuller tests have low power, we apply a Panel test that considers the null of stationarity and corrects for serial dependence using a non-parametric kernel based method.

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1 Introduction

This article considers whether exchange rates satisfy PPP in the long-run by testing whether the real exchange rate is stationary. Univariate tests of stationarity applied to single currencies have tended to accept the null of non-stationarity (e.g., Abuaf and Jourion (1990)). While Hunter and Simpson (1995) found evidence for a six variable model of the UK effective exchange rate that a cointegrating vector could be restricted to satisfy PPP. Lothian and Taylor (1996), using long time series averages, observed that the strength of correlation between the exchange rate and relative prices increased with the length of period used. Peel and Taylor (1999) supported the proposition that PPP held in the long-run based on a non-linear model.

This article uses the non-parametric correction to the stationarity test due to Hadri (2000) to take account of heterogeneous serial dependence across a panel of 12 real exchange rates. The test considers the null of stationarity and for a sample with more than 50 time series observations Hadri shows that it is appropriately sized and has excellent power against close local alternatives. The Hadri test is also robust to certain forms of non-normality.

In section 2, conventional stationarity tests are undertaken, in section 3 results are presented for the non-parametric correction to the panel test and in section 4 conclusions are offered.

2. Evidence for univariate tests based on the null of non-stationarity.

Quarterly observations on dollar real exchange rates were drawn from the Datastream Database for the period (1980q1 – 1998q1) for twelve countries: Italy, Spain, Belgium, Denmark, Finland, France, Germany, Ireland, Luxembourg, Holland, Portugal and UK.

As a preliminary, Augmented Dickey-Fuller tests (Dickey and Fuller (1979)) were applied to each exchange rate. To improve the likelihood that the alternative might be accepted a maximum lag of *(j=5)* was selected, but intermediate lags were excluded on the basis of conventional tests of significance.[1] The following model is estimated without trend:

$$\Delta y_t = \delta_0 + \delta_1 y_{t-1} + \sum \theta_j \Delta y_{t-j} + \varepsilon_t. \quad (1)$$

The results in Table 1 compare critical values for equation (1) calculated under the null (δ_1=0) for a sample of 62 observations. With a 95% critical value of –2.92, only the real exchange rates of France, Ireland and Luxembourg are stationary.

(Table 1 goes here)

Abuaf and Jorion (1990) question the usefulness of univariate ADF tests to detect stationary real exchange rates when the sample is short. This has led to tests based on the null of non-stationarity being applied to Panel Data to improve the power of the test by pooling observations across countries. However, O'Connell (1998) has argued that many of these studies "fail to control for cross-sectional dependence in the data". Luintel (2001) has addressed this issue by applying the demeaned LM-bar and T-bar tests proposed by Im et al (1997) to data for 20 OECD countries. Luintel suggests that the finding of stationarity is due to a reduction in the order of cross-sectional dependence and cites the study by Wu and Wu (1999) where tests based on Deutsche Mark rates appear more likely to accept stationarity.[2]

However, in the context of real exchange rates the primary interest is in testing the null of stationarity and subject to an appropriate level for the test it is subsequently important to minimise the probability of wrongly rejecting the alternative by selecting a locally most powerful test. In this light, Taylor and Sarno (1998) have voiced concerns about tests based on the null of stationarity, which

[1] The asymptotic distribution of the test statistic is not affected by the exclusion of intermediate lags.
[2] It should be noticed that data derived from cross rates, embodies an implicit sequence of cross arbitrage conditions, which affect the structure of the underlying model and the validity of tests. The issue is outlined by Smith and Hunter (1985) for conventional dynamic models, and models that impose PPP and uncovered interest arbitrage. Hence, tests based on cross rates can be directly derived from the respective dollar rates.

have been accepted when only a single series in the panel is viewed as being stationary. The issue of the appropriate null also concerned Caner and Kilian (2001), who found significant size distortion for the KPSS (Kwiatkowski et al, 1992) and Leybourne and McCabe (1994) tests of the null of stationarity. More worryingly after the application of small sample corrections the power properties of the tests also became very poor. This led to the use of the test due to Hadri (2000).

3. Panel evidence for PPP based on a test of the null of Stationarity

Hadri (2000) proposes a Lagrange-Multiplier (LM) test of the null that a series is stationary (either around a deterministic level or a trend). An exact small sample correction to the LM test statistic makes it asymptotically normal. The test has good size properties and is robust to non-normality.

Following the suggestion of Papel (1997) and Luintel (2001), that real exchange rate do not trend, it ought to move around a deterministic level:

$$y_{it} = r_{it} + e_{it} \tag{2}$$

for $t=1\ldots T$ time and $i=1\ldots N$ countries. Equation (2) assumes that the series can be decomposed into a random walk and a stationary disturbance term:

$$r_{it} = r_{it-1} + u_{it} \tag{3}$$

Where, u_{it} are independently and identically distributed across i and over t with s^2_u ³ 0. The test under the null of stationarity, considers the following hypotheses:

$$H_0\text{: } l=0 \qquad \textit{against} \qquad H_1\text{: } l>0.$$

Where, $l = s^2_u / s^2_e$, and $s^2_u = 0$ under the null. The Panel can be presented thus:

$$y_i = X_i B_i + e_i \tag{4}$$

Where, $y¢_i = [y_{i1}\ldots y_{iT}]$, $e¢_i = [e_{i1}\ldots e_{iT}]$ and X_i is a $Tx1$ unit (1) vector. The LM test is:

$$LM = \frac{1}{N}\sum_{i=1}^{N}\frac{1/T^2 \sum_{t=1}^{T} S_{it}^2}{s_i^{*2}}. \tag{5}$$

Where s_i^{*2} is the variance estimated from each individual sample and the partial sum of the residuals is $S_{it} = \sum_{j=1}^{t} e_{ij}$. For comparison with the ADF test, the following semi-parametric correction for serial correlation is applied to each variance term in the panel:

$$s_i^{*2}(x) = g_o + 2\sum_{s=1}^{T-1} k(x) g_s . \qquad (6)$$

Where, $\gamma_0 = s_i^{*2}$, the bandwidth *x=s/l+1*, l is the lag truncation and $g_s = \frac{1}{T}\sum_{t=s+1}^{T} e_{it}e_{it-s}$. A number of choices are available for the kernel *[k(x)]*, each with different properties. Initially, we consider the following simple truncation:

$$\text{Truncated (T): } k_T(x) = \begin{cases} 1 \text{ for x} < 1 \\ 0 \text{ otherwise} \end{cases}$$

Hadri has suggested that the Quadratic-spectral (QS) kernel might be optimal, but for comparison Bartlett (BT) and Tukey-Hanning (TH) kernels are also used. Should the kernel truncate too early, then it might not capture serial correlation. The speed of decay of each kernel can be observed from Table 2. Except for the truncated kernel, the QS kernel has the slowest rate of decay.

(Table 2 goes here)

The following finite sample correction to the LM statistic is asymptotically normal:

$$Z_u = \frac{ÖN\ (LM_u - x_u)}{z_u}$$

From Hadri (2000), ξ_u=1/6 and ζ_u^2 = 1/45. Hadri shows for T≥50, that the empirical size of the test is approximately .054 and for l in the range *[.1, ¥]* the test has maximum power. Test results for the different kernels are summarised in Table 3.

(Table 3 goes here)

It should be noted that the test is one sided, which for a test at the 5% level implies a critical value of 1.645. Ordering the tests by speed of decay, the test statistics based on TH, QS and T kernels all accept the null of stationarity, while the test using the BT kernel marginally fails at the 5% level. It would appear from Table 2 that the BT kernel rejects the null, because it gives less weight to the first seven auto-covariances in (2).

4. Conclusions

The size properties of the Hadri test selected, the ease with which it can be corrected for serial correlation and heteroscedasticity would appear to make it well suited to test whether real exchange rates are stationary on the basis of the sample used here. This is especially true when one considers that the test is not sensitive to the distribution of the data. Whether, it is better to Pool exchange rates or draw together further information from the economy to better explain the exchange rate mechanism is difficult to determine. However, this article suggests that pooling time series appropriately and then testing the null of stationarity goes some way to support the proposition that real exchange rates are stationary.

Appendix 1: Alternative Kernels

The Bartlett Kernel (BT);

$$k_{BT}(x) = \begin{Bmatrix} 1 - |x| \text{ for } |x| \leq 1 \\ 0 \text{ otherwise} \end{Bmatrix}$$

Tukey-Hanning (TH);

$$k_{TH}(x) = \begin{Bmatrix} (1 - \cos(px)/2 \quad for \; \| x| \leq 1 \\ 0 \text{ otherwise} \end{Bmatrix}$$

The Quadratic-spectral (QS);

$$k_{QS}(x) = \frac{25}{12p^2x^2}\left\{ \frac{\sin(6px/5)}{6px/5} - \cos(6px/5) \right\}$$

References

Abuaf, N. Jorion, P. (1990) Purchasing Power in the Long Run, The Journal of Finance XLV, 157-174.

Caner, M., and Kilian, L. 2001. Size Distortions of Tests of the Null Hypothesis of Stationarity: Evidence and Implications for the PPP Debate. Forthcoming in the Journal of International Money and Finance.

Canzoneri et al (1999) Relative Labor Productivity and the Real Exchange Rate in the Long Run: Evidence for a Panel of OECD Countries, Journal of International Economics, 47, 245-266.

Dickey, D.A. and Fuller, W.A. (1979) Distribution of the Estimators for Autoregressive Time Series with a Unit Root, Journal of the American Statistical Association, 74, 427-431.

Hadri, K. (1999) Testing the Null Hypothesis of Stationarity against the Alternative of a Unit Root in Panel Data with Serially Correlated Errors, The Econometrics Journal 3, 148-161.

Hunter, J. and Simpson, M. (1995) Tests of Exogeneity for Long-Run PPP and Uncovered Interest Parity in an Identified Model of the United Kingdom Effective Exchange Rate, Discussion Paper, Brunel University 14-95, presented at ESEM96 in Istanbul.

Im, k. Pesaran, M. and Shin, Y. (1995) Testing for unit roots in heterogeneous panels, unpublished manuscript, Department of Applied Economics (University of Cambridge).

Kwiatkowski, D., Phillips, P.C.B., Schmidt, P. and Shin, Y. 1992. Testing the Null of Stationarity Against the Alternative of a Unit Root: How sure are we the Economic Time Series have a Unit Root? Journal of Econometrics, 54, 159-178.

Leybourne, S.J. and McCabe, B.M.P. 1994. A Consistent test for a Unit Root. Journal of Business and Economic Statistics, 12, 157-166.

Lothian, J.R. and Taylor, M.P. (1996) Real Exchange Rate Behaviour: The Recent Float from the Perspective of the Past Two Centuries, Journal of Political Economy, 104, 488-509.

Luintel, K. (2000) Heterogeneous Panel Unit Root Tests and Purchasing Power Parity, forthcoming in the Manchester School.

O'Connell, P. (1998) The Overvaluation of Purchasing Power Parity, Journal of International Economics, 44, 1-19.

Papell, D.H. (1997) Searching for Stationarity: Purchasing Power Parity under the Current Float, Journal of International Economics, 43, 313-32.

Peel, D.A., and Taylor, M.P. (2000) Non-linear Adjustment, Long-Run Equilibrium and Exchange Rate Fundamentals Journal of International Money & Finance, 19 (1). 33-53.

Sarno, L. and Taylor, Mark P. (1998) Real Exchange Rates under the Recent Float: Unequivocal Evidence of Mean Reversion. Economics Letters. 60 (2). 131-37.

Smith, R.P and Hunter, J, Cross Arbitrage and Specification in Exchange Rate Models, Economics Letters 18, 375-376, 1985.

Wu, S. and Wu, J. (1999) Purchasing Power Parity Under the Current Float: New Evidence from a Panel Data Unit Root Test. Mimeograph, Department of Financial and Managerial Economics, SUNY, Buffalo.

Table 1 Summary of Augmented Dickey Fuller Tests

Country	Test Statistic	Result
Italy	-1.96	non-stationary
Spain	-1.39	n-s
Belgium	-2.36	n-s
Denmark	-1.83	n-s
Finland	-1.36	n-s
France	-2.96	s
Germany	-1.76	n-s
Ireland	-3.69	s
Luxembourg	-3.61	s
Holland	-2.70	n-s
Portugal	-0.84	n-s
UK	-2.83	n-s

(n-s non-stationary, s stationary)

Table 2 Kernel Weightings

S	Truncated	Bartlett (BT)	Tukey-Hanning (TH*)	Quadratic-spectral (QS)
1	1	0.9375	0.9904	0.9945
2	1	0.8750	0.9619	0.9780
3	1	0.8125	0.9157	0.9509
4	1	0.7500	0.8536	0.9139
5	1	0.6875	0.7778	0.8679
6	1	0.6250	0.6913	0.8139
7	1	0.5625	0.5975	0.7531
8	1	0.5000	0.5000	0.6869
9	1	0.4375	0.4025	0.6168
10	1	0.3750	0.3087	0.5443
11	1	0.3125	0.2222	0.4708
12	1	0.2500	0.1464	0.3979
13	1	0.1875	0.0843	0.3270
14	1	0.1250	0.0381	0.2592
15	1	0.0625	0.0096	0.1959

Table 3 Non-parametric correction to Hadri test based on alternative Kernels

Kernel	Test Statistic
Truncated	0.935337
Bartlett	1.662121
Tukey (TH)	1.297038