Is the Real Exchange Rate Stationary? – a Similar Sized Test Approach for the Univariate and Panel cases.

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Abstract

In this article we show that mean-adjusting Panel and Time Series unit root tests yields similar size when there is no drift. The conclusion of the empirics for Purchasing Power Parity is that it holds on average.

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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. PPP is a critical factor in the long-run determination of exchange rates. And much of the recent evidence testing the proposition that the real exchange rate is stationary using Univariate time series would suggest that PPP does not hold as the hypothesis that real exchange rates are stationary is commonly rejected (Abuaf and Jorion, 1990). Though, Hunter and Simpson (1995) found a stationary cointegrating vector accepting the PPP restriction when a small system of equations is estimated to explain the UK effective exchange rate.[1] Lothian and Taylor (1996) found that long-run correlations between the exchange rate and relative prices tended to unity with the length of the time series used and concluded that this evidence supported the proposition that PPP holds in the long run. Luintel (2001), who controlled for cross-sectional dependence in his application of the Panel test of Im, Pesaran and Shin (2001), found evidence for stationarity.[2] However, Sarno and Taylor (1998) have called Panel methods into question as their simulations suggest that such tests may be sensitive to the behaviour of a small number of stationary series. While, Caner and Killian (2001) have observed that many of the tests derived lack power irrespective of the null to be tested.

In this article the logarithm of the real dollar exchange rate series for twelve European countries are de-meaned prior to testing, to eliminate the influence of the constant. The de-meaning corrects the test for initial conditions (Tremayne, 2006, and Haldrup and Jansson, 2006) and as the transformed data defines a mean zero series the Univariate and Panel tests are remarkably similar

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[1] This is distinct from the evidence in Hunter (1992), Johansen and Juselius (1992) and Juselius (1995), for which the PPP has to be augmented by interest rates and similar results for Germany and Italy presented in Simpson (2002).

in terms of size. The recursive mean adjusted Univariate tests are presented, because according to Taylor (2002) they define similar tests and they would also appear to have superior power to the GLS corrected Dickey-Fuller test developed by Elliot, Rothenberg and Stock (1996). The models are all well defined in terms of serial correlation, but where appropriate we use heteroscedasticity consistent standard errors to take some account of the fact the disturbances may not all be identically distributed. We also correct the models for ARCH behaviour in the disturbances where volatility is observed. The corrected Univariate results would suggest that on average the real exchange rate is stationary a proposition supported by our Panel analysis. And, here the concerns voiced by Sarno and Taylor (1998) would not seem to apply or rather the series from which our Panel is drawn are on average stationary with white noise disturbances. To support our Univariate and Panel analysis we test the proposition that the real exchange is stationary using the test due to Hadri (2000), because this test operates under the null of stationarity and unlike similar tests considered by Caner and Killian (2001) has excellent size and power for the sample size available and is robust to non-normality.

For the Univariate time series data the recursive mean transformation suggested by Taylor (1999) is applied and in the case of the t-bar test of Im et al (2003) the data are all relative to their cross sectional country means. The recursively mean adjusted data are also used to generate the individual series pooled in our application of the Hadri test. The sample selected, 1980q1 – 1998q1, avoids the seventies when US prices were integrated of order two (I(2)) and inflation rates for some countries were considered non-stationary. The sample ends before the introduction of the Euro zone.

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[2] The work of Luintel (2001) was applied to an earlier unpublished version of the Im, Pesaran and Shin (2003) paper.

In section 2, theory and policy questions are addressed, in section 3 Dickey Fuller tests are undertaken for the Univariate time series, in section 4 results are presented for the Panel and in section 5 conclusions are offered.

2. THEORY AND POLICY CONSIDERATIONS

PPP is a long established proposition, which dates from well beyond its first technical exposition by Cassel (1922). The theory of PPP is essentially the law of one price applied to a basket of equivalent goods traded internationally. The theory has come under some scrutiny of late and a recent appraisal of much of the literature is presented in Lothian (1998). However, a number of issues have arisen about the coherency of the PPP theory. Firstly short-run day-to-day trading in exchange is dominated by capital flows, which suggests that the exchange rate may deviate from PPP as long as a country's trade deficit is funded. Secondly, it is well known that the nominal exchange rate can be viewed as following a non-stationary time series process or process with a unit root (Baillie and McMahon, 1990).[3] Furthermore, the notion that the time-series process driving the exchange rate has a unit root in discrete time is quite consistent with the theoretical notion of overshooting considered by Dornbusch (1976).

In logarithmic form the PPP hypothesis implies that:

$$e_{12}=p_1 - p_2 \text{ or } y=p_1 - p_2 - e_{12}. \qquad (1)$$

Where e_{12} is natural logarithm of one unit of the home currency, p_1 is the natural logarithm of the home price and p_2 is natural logarithm of the foreign price. When the exchange rate follows a random walk, then e_{12} is by definition an I(1) series and for PPP to hold or the real exchange rate y to be stationary, then $p_1 - p_2$ must also be I(0).

[3] If a time series (y_t) follows a random walk, then $y_t = \phi_0 + \phi_1 y_{t-1} + \varepsilon_t$ has a unit root or $\phi_1=1$ and the series is termed I(1) or integrated of order 1.

The proposition that relative prices and exchange rates converge is an important proposition for monetary policy. Dornbusch style overshooting implies that the exchange rate is likely to move away from its long-run equilibrium value. However, the notion that the nominal exchange rate is non-stationary means that such deviations may be permanent. If exchange rates do deviate from PPP in the long-run, then the economic argument for fixed versus floating exchange rates moves in favour of fixed rates, because of the hedging costs that are associated with exchange rates that are likely to be under or over-valued for significant periods of time. Secondly, governments attempting to protect their financial markets from speculative attacks may be liable to significant financial risk.

Whether real exchange rates are stationary or not has implications for the nature of exchange rate regime that might be viewed as being optimal and on the advisedness of governments attempts to correct significant exchange rate misalignments.

3. UNIVARIATE TESTS FOR NON-STATIONARITY

Quarterly observations on dollar real exchange rates[4] were drawn from the Datastream database over the period (1980q1 – 1998q1) for twelve countries: Italy, Spain, Belgium, Denmark, Finland, France, Germany, Ireland, Luxembourg, Holland, Portugal and UK.

In line with common practice, augmented Dickey-Fuller tests (Dickey and Fuller (1979)) were applied to each exchange rate in turn. It is important to note that the Dickey-Fuller test is sensitive, to initial conditions, dynamics in both the conditional variance (ARCH) and the mean equation (serial correlation), and non-normality. While some of the more recent literature has suggested that there might be some form of non-linear adjustment.

[4]The real exchange rates used are based on relative consumer price indices.

Therefore, prior to specifying the time series auto-regressive model from which the ADF test is derived, we transform the data by recursively de-meaning the series in turn using the procedure described by Taylor (1999). Then for each series we consider the correlogram, under the null of non-stationarity to determine the maximum lag order of each model of the real exchange rate (Burke and Hunter, 2005, Chapter 2). This corresponds with the view presented in Said and Dickey (1984) that long order AR models improve size, though the introduction of redundant lagged terms may also lead to a loss of power (Haldrup and Jansson, 2006). To improve the power of the Univariate tests we follow a General to Specific approach (Taylor, 2002) and discard intermediate lags that are insignificant at the 10% level based on conventional inference. And on the basis of both conventional inference and simulated critical values we exclude the intercept.[5] As there is no trend in the original data and the asymptotic distribution of the Dickey-Fuller test is not sensitive to the inclusion of differenced series we apply the test to the following model:

$$\Delta x_{it} = \gamma x_{it-1} + \sum_{j=1}^{l} \pi_j \Delta x_{it-j} + \varepsilon_{it}. \qquad (2)$$

Where $x_{it}=y_{it}-\sum_{j=s}^{t} y_{it-j}/t$ is the recursively de-meaned real exchange rate for country i. The results in Table 1 compare critical values for equation (2) calculated under the null of non-stationarity (γ=0) for a sample of 68 observations. Using the 95% critical values simulated by Ox (Doornik, 2006) as -1.9714,[6] the real exchange rates

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[5] As can be observed from Table 1, the intercepts for the de-meaned series are small and when an intercept is included in the regression these are neither significant based on conventional inference or on the basis of critical values simulated under the null associated with the Dickey-Fuller test in the case with an intercept. Simulations are based on 1000 replications generated with an intercept in the regression and a standard deviation of 1 and .0387 using the AR(1) model in first differences in PC-Naïve (Doornik and Hendry, 2006). This gave rise to t-values -3.0345 and -3.4051 respectively based on an intercept of -.008.

[6] Simulations are generated for T=68 and B=10000 replications. The data are calibrated using a typical real exchange rate series with the recursive mean transformation used to remove the initial condition. For a nominal size of the test of 95%, the rejection frequency is 96.3% so the tests are slightly undersized leading to an over acceptance of the null. Therefore, the true critical value ought to be greater than the value we have simulated.

of Belgium, France, Finland, Germany, Holland, Ireland and the UK[7] are stationary.

Based on a similar argument to Phillips and Peron (1988) we provide corrected standard errors to determine the tests for stationarity. Firstly, we apply White's (1982) standard errors to the conventional Dickey-Fuller t-test and this yields a standardised estimate of the residual variance that has no significant impact on the behaviour of the mean equation.[8] This is useful for a number of reasons: alternative estimates of the standard errors are less sensitive to the risk of pre-test bias that may arise due to the initial exclusion of variables in the auto-regressive equations that describe the real exchange rate, and they remove the impact of extreme observations on the estimate of the error variance. Hence, White standard errors are used to correct the error variance for the undue influence of large observations reflected in the Jarque-Bera statistics reported in Table 1.

(Table 1 goes here)

As a result of this transformation all the reported Dickey-Fuller test statistics increase for all the cases excepting Spain. Using inference based on White Standard errors,[9] the real exchange rate is stationary for eight out of the ten countries at the nominal 5% level, while in the case of Denmark this would be true when the test might be applied at the 10% level. However, for Spain stationarity cannot be accepted at any conventional level of significance. It is of particular interest to note that the substantive increases in the test statistic occurs when the models residuals test significant for non-normality.

[7] Luxembourg has the same exchange rate as Belgium, but a different price series.

[8] This is essentially the same as applying the first term in the semi-parametric correction used by Phillips and Peron (1988), but here we are not concerned with serial correlation. However, we would anticipate with some large outliers that the White Standard errors would yield more robust inference, while making little difference to the underlying distributions associated with the test of stationarity.

[9] Based on the same simulated data as before the corrected test has the following critical value, -1.6861 (90%) and -2.0244 (95%) with the empirical size of the test being 92% and 0.95885%. respectively.

In the case of two countries, Luxembourg and Portugal, there is evidence in column four of Table 1 of Auto-regressive Conditional Heteroscedasticity (ARCH). Here, we clean up the variance estimates by estimating the ADF model using the ARCH estimator to correct for observed volatility. Boswijk (2001) has suggested that by modelling the volatility the power of unit root tests might be greatly improved. In the case of Luxembourg and Portugal the standard errors are derived using the ARCH (1) and the restricted ARCH (4) estimator. It is suggested in Boswijk (2001) that for the near integrated case, conventional inference should be acceptable, as long as the two Brownian Motions driving the process are not correlated. This would appear to be the case for GARCH and any other process explaining the volatility - when they have a continuous-time diffusion limit. In this light, we assume for ARCH processes that are not integrated that the asymptotic theory goes through. In the case of Luxembourg this means that it is possible to accept the alternative hypothesis of stationarity at the 5% level. However, based on all of the inferential procedures adopted here, it is not possible to accept that the real exchange rate is stationary in the case of Portugal.

Given the misspecification that arises with ARCH it would appear appropriate to use corrected standard errors as compared with those derived from OLS that are biased and in some instances inconsistent. If one were to accept conventional inference, then the models do not suffer from serial correlation, heteroscedasticity and non-linearity. However, for all but two cases the errors are non-normal and in two further cases there is significant ARCH behaviour that leads us to adopt variance estimates that differ from the conventional OLS ones.

Following the suggestion made by Abuaf and Jorion (1990) to pool data due to the size of the sample, tests based on the null of non-stationarity have been applied to Panel data, in an attempt to improve their power. However, O'Connell

(1998) has argued that Panel studies “fail to control for cross-sectional dependence in the data”. Luintel (2001) has addressed this issue by applying the de-meaned LM-bar and T-bar tests (Im et al, 2003) 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 denominated exchange rates appear more likely to accept stationarity.[10] 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. Unfortunately, Taylor and Sarno (1998) have shown for the tests regularly adopted in Panel estimation that stationarity might be accepted even when a single series alone is truly stationary. The issue of the appropriate null for many of the conventionally used tests has also concerned Caner and Kilian (2001), who found significant size distortion for the KPSS (Kwiatkowski et al, 1992) and Leybourne and McCabe (1994) tests that are both derived under the null of stationarity.

On the basis of the research presented thus far, we can say by careful analysis of each series in turn that on average the series selected here do appear to be stationary; unlike the simulations of Sarno and Taylor. Of course our single equation analysis would suggest that real exchange rates are fairly heterogeneous and this would suggest that one ought not to be engaged in any form of pooling. We will apply Panel methods under the assumption that the pooled series broadly satisfy the appropriate criterion. Firstly, the test by Im et al (2003) has the merit of pooling t-tests derived from appropriately calibrated country series; the Univariate

[10] It should be noticed that data derived from cross rates, embodies an implicit sequence of cross arbitrage conditions,that affect the structure of the underlying model and the validity of tests. See Smith and Hunter (1985) for conventional dynamic models, and models that impose PPP and uncovered interest arbitrage, and Hunter and Simpson (2004) for dynamic single equations models. Thus the variance-covariance matrix of the parameters is incorrect under both null and alternative, while the estimate of g is biased and inconsistent.

series are all scaled relative to their cross-section means. Then for comparison, the test due to Hadri (2000) is applied to the recursively de-meaned data and it has been selected relative to other tests under the stationary null, because it offers significant gains in terms of size and power. More importantly, given our sample it is robust to non-normality and the convergence in distribution occurs quickly in small cross sections with a quite modest time series dimension and for a broad range of values of the variance ratio implicitly being minimized by the test.

4. PANEL TESTS FOR PPP UNDER THE NULL OF NON-STATIONARITY AND STATIONARITY

Im et al (2003) suggest a test of stationarity that averages the conventional Dickey-Fuller test statistics across the Panel, while 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 means that the test is asymptotically normal. Furthermore, Hadri (2000) provides evidence that after correction the test has good size properties and is robust to non-normality.

Luintel (2001) addresses this issue by applying the tests proposed in an earlier version of the article by Im et al (2003) to data for 20 OECD countries. The real exchange rate equation without transformation is:

$$Dy_{it} = p_{i0} + g_i y_{it-1} + \mathring{a} p_{ij} D_1 y_{it-j} + e_{it} \qquad (3)$$

and when de-meaned:

$$\Delta ?_{it} = \tilde{d}_{it} + \beta_i ?_{it-1} + \Sigma\theta_{ij}\, \Delta ?_{it-j} + ?_{it} \qquad (4)$$

where: $\tilde{y}_{it} = y_{it} - \bar{y}_t$, $\tilde{d}_{it} = d_{it} - \bar{d}_t$, $\tilde{e}_{it} = e_{it} + q_t - \bar{e}_t$, $?_t$ is the time-specific common fixed effect and $x_{it} = \tilde{e}_{it} + \frac{1}{N}\Sigma_{j=1}^{N}(b_i - b_j) y_{jt-1}$. We consider the t-bar test or average Dickey Fuller test based on estimating (4) for each cross section observation and calculating:

$$\bar{t}_{NT} = \frac{1}{N}\sum_{j=1}^{N} t_{iT} \,. \qquad (5)$$

The null tested is that all the coefficients are consistent with non-stationarity:

$H_0 : b_i = 0 \;\; for \;\; i=1\ldots N$

$H_A : b_i < 0 \;\; for \; i=1\ldots N.$

The test is compared with a critical value simulated by Im et al (2003), with $\bar{t}_{12,70} = -2.0028$.[11] When compared with a 5% critical value of –1.96 with p-value of 0.0249 the null is rejected and the joint hypothesis of stationarity is also accepted for this Panel.

For comparison we consider the test due to Hadri (2000), which is derived under the null of stationarity. Following the suggestion of Papell (1997) and Luintel (2001) that real exchange rates associated with developed economies are not trended, the version of the real exchange rate (y_{it}) is assumed to move around a deterministic level:

$$y_{it} = r_{it} + e_{it} \qquad (6)$$

where $t=1\ldots T$ time periods and $i=1\ldots N$ countries.[12] Equation (6) assumes that the series can be decomposed into a random walk and a stationary disturbance term:

$$r_{it} = r_{it-1} + u_{it} \qquad (7)$$

where, u_{it} are independently and identically distributed across i and over t with s^2_u ³ 0. The test that the real exchange rate is stationary, considers the following hypotheses:

$$H_0\!: l=0 \qquad against \qquad H_1\!: l>0,$$

[11] Looking at Table 4 in Luintel (2001) for the European Community, $\bar{t}_{11,100} = -2.128$.

where, $l = s^2_u/s^2_e$, and $s^2_u = 0$ under the null. Each equation in the Panel can be presented thus:

$$y_i = X_i B_i + e_i \tag{8}$$

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:

$$LM = \frac{1}{N} \Sigma_{t=1}^{N} \frac{1/T^2 \, \Sigma_{t=1}^{T} S_{it}^2}{s_i^{*2}}. \tag{9}$$

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 non-parametric correction for serial correlation is applied to each variance term in the Panel:

$$s_i^{*2}(x) = g_o + 2\sum_{s=1}^{T-1} k(x) g_s. \tag{10}$$

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:

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

Hadri has suggested that the Quadratic-spectral (QS) kernel might be optimal, but for comparison results for the Bartlett (BT) and Tukey-Haning (TH) kernels are also presented. Should the kernel truncation operate too early, then serial correlation in one of the series might not be appropriately modelled. The speed of decay of each kernel can be observed from Table 2. Except for the truncated kernel, the QS kernel appears to decay at the slowest rate.

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[12] If (4) has zero variance then r_{it} is a constant series and y_{it} is stationary otherwise the series is driven by a stochastic trend.

(Table 2 goes here)

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

$$Z_u = \frac{\sqrt{N}\,(LM_u - \xi_u)}{\zeta_u}. \qquad (11)$$

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 λ in the range $[.1,4]$ the test has maximum power.[13] 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. As Hadri (2000) suggests that the test is slightly undersized, a test with nominal size of 5% is actually being undertaken at the 4.5% level that would suggest the null of stationarity might here be accepted, even in the case of the BT kernel.

5. CONCLUSIONS

There is now a body of evidence that would suggest that the real exchange rate is stationary. This study along with a number of others, notably Luintel (2001) appears to find support for the proposition when the null of non-stationarity is used. Here, our Univariate analysis follows from a careful assessment of the behaviour of the Univariate series. After the selection of appropriate lags and mean adjustment we produce models that are well defined and seem to accept the proposition that for

[13] For the sample used in this article, the test can distinguish perfectly cases for which the variance of the stochastic trend is greater than one tenth of the variance of the real exchange rate after correction for serial correlation.

9 of the 12 countries analysed, real exchange rates are stationary. If one uses a broader test criterion (10%), based on the notion that incorrect rejection of the alternative is more important than incorrect rejection the null, then we can also conclude that the real exchnage rate for Denmark is stationary. This compares with three countries when these corrections are not applied (Simpson (2002)).

When we apply the analysis to a Panel of unit root tests using the procedure due to Im et al (2003), we come up with very similar conclusions to Luintel (2001). Hence, our acceptance of the t-bar test implies that on average the series investigated are I(0) or on average the real exchange rate is stationary. And both the Univariate and the Panel analyses based on the null of non-stationarity come to the same conclusion. This evidence would seem to obviate the concern of Sarno and Taylor (1998) that the Panel result may be driven by a small sub-set of stationary series. However, the paper by Sarno and Taylor would suggest that a Panel analysis should be supported by the Univariate results.

To counter the concerns about the performance of Dickey-Fuller tests, we support our Panel and Univariate analysis by a further study based on the null of stationarity. This is quite consistent with the argument made in Kwiatowski et al (1992) to confirm the KPSS test with tests under the null of non-stationarity. As Caner and Killian (2001) have voiced their reservations about the KPSS test and the test due to Leybourne and McCabe (1994) we apply the test proposed by Hadri (2000), but on our mean adjusted data. The Hadri test takes account of dynamic heterogeneity, corrects for both serial correlation and heteroscedasticity and has optimal size and power for the sample selected in this study. Furthermore, the test appears not to be sensitive to the underlying distribution of the data and the underlying hypothesis tested is that real exchange rates are stationary. The final test applied to a Panel of de-meaned real exchange rates would appear to confirm our findings that for the eighties and nineties real exchange rates were predominantly stationary.

APPENDIX

<u>Alternative Kernels</u>

The Bartlett Kernel (BT);

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

Tukey-Hanning (TH);

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

The Quadratic-spectral (QS);

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

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Table 1 Summary of Augmented Dickey Fuller Tests

Country	t-OLS/t-W	Mean	ARCH(4)	BP(9)	JB(2)	LR(i)
Belgium	-2.36/-2.96	.000517	1.5619	4.5313	18.4357	2.9582(4)
Denmark	-1.62/-1.7	.0010700	1.9120	9.1640	1.6948	1.3307(4)
France	-2.51/-3.02	.1803E-3	2.3684	4.4180	63.9455	1.9710(2)
Finland	-2.07/-2.17	-.0021874	1.7105	1.4099	41.0066	.10537(2)
Germany	-2.33/-2.51	.0010926	2.3639	6.8697	1.1113	.45821(3)
Holland	-3.28/-3.36	.4953E-3	6.0082	4.7406	3.2804	.33688(3)
Italy	-1.86/ -2.3	-.1929E-3	2.1029	9.5322	139.1943	1.4761(3)
Luxembourg	-1.85/-2.60	.1373E-4	22.0553	2.0923	47.2989	.063297(3)
Ireland	-2.26/-2.12	-.6408E-3	2.8921	6.5168	8.5586	3.0704(4)
Portugal	-.93/-1.08	.0011172	12.7212	4.8049	95.3690	1.7532(3)
Spain	-1.54/-1.47	.1536E-5	5.0087	4.8213	10.1260	2.5905(3)
UK	-2.06/-2.19	.0013465	1.3039	7.0078	13.4754	2.0265(4)

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
Quadratic (QS)	0.925401