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Abstract: Cointegration Tests of Purchasing Power Parity
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In recent work Im, Lee, and Enders (2006) use stationary instrumental variables to test for cointegrating relationships. The advantage of their approach is that the t-statistics are asymptotically standard normal and the familiar critical values of the normal distribution may be used to assess significance. Thus, the test avoids the nuisance parameter problem in single equation regressions for cointegration. Using an updated version of the data set developed by Taylor (2002), the ILE test is compared to three single equation alternatives in testing for purchasing power parity: An error correction model, autoregressive distributed lag model, and the Engle-Granger two step procedure. The regressions with instruments provide evidence supportive of PPP for some countries but the empirical results differ across tests and the choice of instrument can affect the results.

Introduction

The hypothesis of purchasing power parity (PPP) has been the focus of much empirical work. Simply stated, PPP says that the price of a market basket of (traded) goods is the same everywhere in terms of a common currency. The concept is important because theories in open economy macroeconomics imply PPP as a long run equilibrium condition. A partial list of techniques used in such empirical work includes single equation unit root tests, cointegration studies, and panel unit root tests. Some of these methodologies have been adapted for use as nonlinear procedures. Underlying the PPP hypothesis is the law of one price (LOOP), which indicates that the price of a (traded) good is the same in all locations in terms of a common currency. Rather than focus directly on PPP, numerous studies have examined the LOOP with the idea that support for the law of one price suggests support for PPP. Sarno and Taylor (2002) provide a thorough review of the PPP and LOOP literature.

The purpose of this paper is to compare the results from standard, single equation cointegration tests of purchasing power parity with those from an alternative approach recently developed by Im, Lee, and Enders (2006), henceforth ILE. Tests are carried out using the data set on nominal exchange rates and price levels containing 100+ annual observations for twenty countries constructed by Taylor (2002), updated to 2007.[1] Applying the Elliot, Rothenberg, and Stock (ERS, 1996) unit root test to transformed (demeaned or detrended) real exchange rate data, Taylor finds support for PPP with respect to the US dollar in eighteen of nineteen series. Only data for Japan fail to indicate PPP for either transformed series. When purchasing power parity is tested on real exchange rates with respect to a world market basket, Taylor finds evidence in favor of the hypothesis using demeaned or detrended data in nineteen of the twenty

[1] A list of countries and periods of coverage are provided in Appendix A. Data for Argentina are only available to 2006. The Taylor data also include information for three additional countries (Chile, Greece, and New Zealand) not reported in Taylor (2002). Data for these three countries is included in this study.

series. Data for Canada fail to reveal any support for PPP. Lopez, Murray, and Papell (2005) argue that Taylor's strong affirmation of PPP can be attributed to the selection of suboptimal lag length in his unit root tests. Employing optimal lag length selection criteria, they conclude that the data support PPP with respect to the US in just nine of sixteen countries.[2] Instead of relying on unit root tests, Wallace and Shelley (2006) apply the Fisher-Seater test with bootstrapped errors to the Taylor data and conclude that PPP holds for at least twelve of nineteen countries with respect to the dollar. Various other studies of PPP have been undertaken using the Taylor data.

Methodology

The well-known single equation tests for cointegration have asymptotic distributions which are not standard normal and which may depend on an unknown nuisance parameter. Pesavento (2004, 2007) evaluates the power of various cointegration tests and shows that test power is dependent on the value of a nuisance parameter, the correlation between the errors of the cointegrating relationship and the right hand side variables. In her study of residual-based tests, she finds that power is low in all tests when the nuisance parameter is large. Im, Lee, and Enders offer an intuitively appealing solution to the nuisance parameter problem by employing stationary variables as instruments in three well-known cointegration tests. With stationary instrumental variables there are no nuisance parameters and the asymptotic distributions of the test statistics are standard normal. In applying their methodology to money demand in the United Kingdom, they find that the results are robust to the choice of instrument. A brief description of the ILE methodology, using their notation, is provided to assist in understanding the empirical results. For more detailed treatment see their working paper.

[2] They eliminate Argentina, Brazil, and Mexico from their study. Their data are updated to 1998.

Starting with a VAR(p) model in which the variables are cointegrated, ILE derive a vector error correction model (VECM) of the form given by equation (1)

$$\Delta y_{1t} = (d_{11} + d_{12}t) + \delta_1 z_{t-1} + \phi \Delta y_{2t} + C_{11}\Delta y_{1t-1} + C_{12}\Delta y_{2t-1} + v_t \qquad (1)$$

where y_{it}, t = 1,2, …T, i = 1,2, are I(1) processes, the d_t are deterministic terms, $z_{t-1} = y_{1t-1} - \beta y_{2t-1}$, and v_t is a linear combination of the normally distributed and independent errors of the original VAR.[3] The VECM derived from the original VAR reduces to a single equation if y_{2t} is weakly exogenous as will be assumed in the empirical work of this study. The null (of no cointegration) and alternative hypotheses are given by

$$H_0: \delta_1 = 0 \qquad H_1: \delta_1 < 0.$$

Alternatively, the error correction model (ECM) can be rewritten as the autoregressive distributed lag (ADL) in equation (2)

$$\Delta y_{1t} = (d_{11} + d_{12}t) + \delta_1 y_{1t-1} + \gamma y_{2t-1} + \phi \Delta y_{2t} + C_{11}\Delta y_{1t-1} + C_{12}\Delta y_{2t-1} + v_t \qquad (2)$$

with the same null and alternative as the ECM test.

The Engle-Granger (EG) test, of course, is a two step procedure whereby i) y_{1t} is regressed on y_{2t} using ordinary least squares and ii) the estimated residuals are tested for a unit root as in equation (3),

$$\Delta\left(y_{1t} - \hat{\beta} y_{2t}\right) = \delta_1\left(y_{1t-1} - \hat{\beta} y_{2t-1}\right) + C(L)\Delta\left(y_{1t} - \hat{\beta} y_{2t}\right) + u_t \qquad (3)$$

where $\hat{\beta}$ is the estimated vector of parameters from $y_{1t} = (d_{11} + d_{12}t) + \hat{\beta} y_{2t} + \varsigma_t$, with d_{11} as an constant, t as an time trend, and the $C(L)\Delta\left(y_{1t} - \hat{\beta} y_{2t}\right)$ are lags of the estimated residuals. The null and alternative hypotheses are

$$H_0 : \delta_1 = 0 \qquad H_1 : \delta_1 < 0$$

[3] ILE assume normality of the errors for convenience and point out that the assumption does not affect the asymptotic results.

Weak exogeneity is not necessary for the EG test. In all three tests, δ_1 has a nonstandard distribution under the null.

In place of the nonstationary (under the null) regressors ILE suggest using instrumental variables (IV). Specifically, they define the instrument w_t as:

- $w_t = z_{t-1} - z_{t-m-1}$ for z_{t-1} in (1)
- $w_t = [(y_{1t-1} - y_{1t-m-1}), (y_{2t-1} - y_{2t-m-1})]$ for (y_{1t-1}, y_{2t-1}) in (2)
- $w_t = (y_{1t-1} - \hat{\beta} y_{2t-1}) - (y_{1t-m-1} - \hat{\beta} y_{2t-m-1})$ for $y_{1t-1} - \hat{\beta} y_{2t-1}$ in (3)

with m < T. ILE suggest increasing m when autocorrelation is present. A constant with or without trend may be added to each equation. ILE show that the t statistic for $\delta_1 = 0$ (t_{ECM}, t_{ADL}, or t_{EG}) in the equation with instruments has a standard normal distribution for a variety of specifications provided any other nonstationary variables are instrumented. Furthermore, they note that the estimated coefficient $\hat{\delta}_{1i}$ $(\hat{\delta}_{1ECM}, \hat{\delta}_{1ADL}, or \hat{\delta}_{1EG})$ is consistent.[4]

An unresolved issue in their tests concerns the optimal selection of m. Neither theory nor their empirical work offers a resolution. In simulations they explore the use of different values of m and in an application of their methodology to money demand in the United Kingdom, they find that the results are robust to alternative values of m. In a related paper Enders, Lee, and Strazicich (2007) suggest selecting the value of me that minimizes the sum of the squared residuals.

Data and Empirical Results

The Taylor data set consists of annual observations on nominal exchange rates and price indexes for the twenty-three countries listed in Appendix A. The nominal exchange rate is measured as the price of a US dollar in units of the foreign currency.

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[4] Again, see ILE for proofs and more detail.

For each country except Chile, Greece, and New Zealand the data span more than 100 years and end in 2007 (again, 2006 in the case of Argentina).

Given that integrated variables are a necessary condition for the presence of a cointegrating relationship, a series of unit root tests are applied to the logged nominal exchange rate and logged price level data. Augmented Dickey-Fuller, ERS, and the KPSS [Kwiatkowski et. al. (1992)] tests are used. Two specifications of each test are conducted, one with only a constant and the other with a constant and trend. In the case of the ADF and ERS tests, the Schwarz criterion is used to select lag length. The first two tables in Appendix B display the test statistics for the nominal exchange rate and the price level for each country.

With a few exceptions, the unit root tests on the nominal exchange rates suggest that they are nonstationary. In the case of Norway, the inclusion of a trend in the ADF and ERS tests leads to rejection of the unit root null while a trend in the KPSS test suggests failure to reject the null of stationarity. Since the graph of Norway's nominal exchange rate clearly shows upward movement, albeit with substantial variation, the tests with trend are more likely correctly specified. Thus Norway's nominal rate appears trend stationary. Similarly, results for the ADF and ERS tests with trend for Sweden and Denmark also indicate rejection of the unit root null, although the KPSS tests reject the stationarity null in these two instances. Despite isolated contrary results, the general conclusion for all other countries is that the nominal exchange rates are nonstationary.

Except for Portugal and New Zealand the tests suggest that the price level in each country has (at least) one unit root. In the cases of Portugal and New Zealand the test results are ambiguous. Those inclusive of a trend generally suggest trend stationary price levels in the two countries, those without indicate unit roots.

It should be noted that the PPP cointegration tests could be valid even in cases when either a country's price level or nominal exchange rate, but not both, are stationary or trend stationary.[5] Specifically, purchasing power parity implies a cointegrating relation between the logs of the dollar denominated price level and the US price level, as shown in equation (4)

$$f_t = p_t^F - e_t = \alpha + \beta p_t^{US} \tag{4}$$

where e_t is the log of the price of a US dollar in terms of the foreign currency, p_t^{US} is the log price level in the United States, p_t^F is the log foreign price level, while f_t is the dollar denominated foreign price level. The dollar denominated price level will be a unit root process if one of its components has a unit root even if the other is stationary or trend stationary. Indeed, the tests, shown in Table B-3 of the appendix, indicate that the dollar-denominated price level has at least one unit root for each of the five countries in which the previous unit root tests did not clearly indicate that either the nominal exchange rate or the price level was an integrated process.

To determine whether a second unit root is present in the data, the same series of tests (ADF, ERS, KPSS with and without trend) are applied to the first differences of the logs of the nominal exchange rate, price level, and dollar-denominated price level for each country (Tables B-4 to B-6 of the appendix). For all countries the results suggest the first difference of the log exchange rate is stationary, thus all nominal exchange rates are I(1) processes.

For most countries the first difference of the logged price level also appears stationary, thus the price level generally appears integrated of order one as well. France, Portugal, Spain, Greece, and New Zealand are exceptions. In the first three cases, the results of tests for a second unit root in the price levels are ambiguous. The results also

[5] Except for the US price level which must be integrated since the dollar is the numeraire currency,

suggest that the Greece and New Zealand have unit roots in their first differenced price levels. For Greece, this clearly suggests that the logged price level has (at least) two unit roots. But since the tests are ambiguous regarding a unit root in New Zealand's price level, the results should be considered inconclusive regarding a second unit root. Finally, for the five countries with either uncertain results or indications of a second unit root in the price level, the first difference of the dollar-denominated price level is stationary for France, Spain, and New Zealand while results are inconclusive for Greece and Portugal.

Given the unit root tests results, the dollar-denominated price levels appear to be I(1) for all countries except Greece and Portugal. Consequently, the cointegration tests are not applied to data for Greece and Portugal, leaving the bilateral exchange rate series for twenty countries with respect to the U.S. dollar in the data set. Despite the confusing results concerning the degree of integration of the price level in New Zealand, the cointegration tests for PPP are applied to data for this country, although, the findings ought to be interpreted with some caution in light of the ambiguous results from unit root tests. For convenience, all test conclusions are summarized in Table B-7.

Absolute purchasing power parity implies the coefficient restrictions $\alpha = 0$, $\beta = 1$ in equation (4) but due to the use of price indices rather than actual measures of the cost of a common market basket, equation (4) with these restrictions rarely holds. But the basis of cointegration tests is that PPP implies the existence of a cointegrating relation between f_t and p_t^{US}. The ECM, ADL, and EG cointegration tests for purchasing power parity, equations (1)-(3), can be rewritten as equations (5)-(7), respectively.[6]

$$\Delta f_t = d_{11} + \delta_1\left(f_{t-1} - \alpha - \beta p_{t-1}^{US}\right) + \phi \Delta p_t^{US} + \nu_t \quad (5)$$

[6] Since the PPP relationship does not include a deterministic time trend; t is omitted from the empirical models.

The expression in parentheses in equation (5) is the error, lagged one period, from the estimation of equation (4), that is, the error correction term. Again the US price level, p_t^{US} is assumed to be weakly exogenous.

The ADL form of the model is

$$\Delta f_t = d'_{11} + \delta_1 f_{t-1} + \gamma' p_{t-1}^{US} + \phi \Delta p_t^{US} + \nu_t \tag{6}$$

where $d'_{11} = d_{11} - \delta_1 a$ and $\gamma' = -\delta\beta$. For the ECM and ADL versions, the same null and alternative apply,

$$H_0: \delta_1 = 0 \qquad H_1: \delta_1 < 0.$$

The null indicates the absence of a cointegrating relation between the US price level and the foreign dollar denominated price level thus failure to reject the null would imply that PPP does not hold. Lagged values of Δf_t and/or Δp_t^{US} are added to equations (5) and (6) as needed to address serial correlation. Finally the Engle-Granger two step procedure involves testing for a unit root in the estimated residuals from the empirical counterpart of the PPP relation given by equation (4).

$$\Delta\left(f_t - \hat{\alpha} - \hat{\beta} p_t^{US}\right) = \delta_1\left(f_{t-1} - \hat{\alpha} - \hat{\beta} p_{t-1}^{US}\right) + \sum_{i=1}^{j} \phi_i \Delta\left(f_{t-i} - \hat{\alpha} - \hat{\beta} p_{t-i}^{US}\right) + u_t \tag{7}$$

Each of the single equation empirical models given by (5)-(7) is estimated and the results compared to estimations using the instrumental variables w_t where

- $w_t = \left(f_{t-1} - \alpha - \beta' p_{t-1}^{US}\right) - \left(f_{t-m-1} - \alpha - \beta' p_{t-m-1}^{US}\right)$ for $f_{t-1} - \alpha - \beta' p_{t-1}^{US}$ in (5)
- $(w_{1t}, w_{2t}) = \left[\left(f_{t-1} - f_{t-m-1}\right), \left(p_{t-1}^{US} - p_{t-m-1}^{US}\right)\right]$ for $\left(f_{t-1}, p_{t-1}^{US}\right)$ in (6)
- $w_t = \left(f_{t-1} - \hat{\alpha} - \hat{\beta}' p_{t-1}^{US}\right) - \left(f_{t-m-1} - \hat{\alpha} - \hat{\beta}' p_{t-m-1}^{US}\right)$ for $\left(f_{t-1} - \hat{\alpha} - \hat{\beta}' p_{t-1}^{US}\right)$ in (7)

Breusch-Godfrey Lagrange multiplier (LM) tests for serial correlation are applied to the initial estimation of the error correction model, equation (5). Results for sixteen of the countries show evidence of serial correlation as the p values on the obs*R^2

statistics are all less than 15%. Up to 4 lags of the dependent variable are added to the ECM specification if the marginal significance level for the Obs*R^2 stat is .15 or less. Lags are added until the marginal significance level exceeds .15. In a few cases serial correlation persists even with 4 lags of Δf_t. In such instances, one lag of Δp_t^{US} is added to the ECM specifications with 0-4 lags of Δf_t until the LM test produces a p value exceeding .15. One of these two approaches successfully eliminates serial correlation (by the criterion employed) in the ECM for each country (see Table 1). Of interest is how results from the tests with instrumental variables compare to those from the standard specifications. Consequently, the same number of lags used to eliminate autocorrelation in the basic ECM is employed in estimations with instrumental variables.

Estimated values of δ_1 and associated t-statistics from the error correction model and the ECM variants estimated with instrumental variables are shown in Table 2. Marginal significance levels and critical values for the ECM estimations are determined using the response surfaces in Ericsson and MacKinnon (2002), implemented in the program ECMtest.xls (version 1.0). As mentioned previously, Im Lee and Enders show that the t-statistic on δ_1 in all three versions of the cointegration tests is asymptotically normal so that the critical value of -1.645 (5% level in a one-tailed test) may be used to assess significance. The estimation results suggest moderate support for purchasing power parity, half of the countries display estimated coefficients on the error correction term (column 2) that are significant at the 5% level or better. Conclusions from equations estimated with instruments are similar with ten countries having significant coefficients in at least three of the four specifications using instruments. NA appears in the table, in some cases, because the instrument with m=4 is highly collinear in model specifications with multiple lags of Δf_t and/or Δp_t^{US} making the estimated coefficients meaningless. A somewhat disconcerting aspect of the IV estimations is that results vary at times with the choice of m suggesting some sensitivity to the selection of the instrument. Indeed, just five of the estimations fail to yield a single significant coefficient on at least one of the instruments. Examining the results from the regression specifications that minimize the sum of the squared residuals (SSR) reveals that the coefficient on the IV is significant in twelve cases.[7] The particular value of m that minimizes the SSR shows no clear pattern in the results; in six instances m = 4 minimizes the SSR while in 5 cases an IV with m = 12 does so.

Table 1-Lags and Variables Included to Eliminate Serial Correlation in the Error Correction Model

Country	Lags of Δf_t	Lags of Δp_t^{US}	p value of LM test in final specification
Argentina	0	0	.436
Australia	0	0	.283
Belgium	1	0	.174
Brazil	4	0	.175
Canada	3	1	.182
Chile	0	0	.527
Denmark	1	0	.518
Finland	1	0	.377
France	1	0	.323
Germany	0	0	.855
Italy	2	0	.316
Japan	1	0	.250
Mexico	1	0	.288
Netherlands	1	1	.743
New Zealand	1	0	.452
Norway	1	1	.827
Spain	1	1	.727
Sweden	2	0	.179
Switzerland	2	0	.174
UK	4	0	.337

[7] The sample period for all cointegration tests for a country, regardless of m, is restricted to be the same as that possible for m = 12. For example, for Australia there are data for 1870-2007. To calculate the appropriate instrument when m = 12, the first twelve observations are lost so that the estimation period is 1882-2007. All other specifications for Australia are estimated over this restricted sample, 1882-2007, so that the results are comparable for different values of m and for the different models. The coefficient from the regression having the minimum sum of squared residuals is italicized in bold font in all tables showing coefficient estimates, i.e. Tables 2, 4, and 5.

Table 2 Estimated δ_1 in Error Correction Model, Without and With Instruments

	Error Correction	Instrumental Variable			
Country		m = 4	m = 7	m = 9	m = 12
Argentina	-0.364*	-0.465*	-0.175	-0.239*	***-0.400****
t-stat	-4.889	-4.134	-1.521	-2.551	-4.234
Australia	-0.148	***-0.140***	-0.139	-0.126	-0.132
t-stat	-2.357	-1.059	-1.174	-1.098	-1.204
Belgium	-0.481*	***-0.481****	-0.306*	-0.299*	-0.325*
t-stat	-5.285	-2.298	-2.262	-2.149	-2.147
Brazil	-0.171	NA	-0.253*	***-0.171****	-0.115
t-stat	-3.108		-2.217	-1.811	-1.451
Canada	-0.217*	NA	-0.099	-0.143*	***-0.269****
t-stat	-3.823		-1.254	-1.997	-3.723
Chile	-0.281*	***-0.261****	-0.239*	-0.303*	-0.307*
t-stat	-3.534	-2.061	-2.225	-2.800	-2.765
Denmark	-0.183*	-0.091	-0.219*	***-0.168****	-0.157*
t-stat	-3.413	-0.953	-2.722	-2.016	-1.957
Finland	-0.599*	-0.612*	-0.587*	-0.650*	***-0.598****
t-stat	-7.746	-4.877	-4.876	-5.164	-4.637
France	-0.196	***-0.240****	-0.257*	-0.258*	-0.082
t-stat	-3.121	-1.726	-1.956	-1.833	-0.542
Germany	-0.169*	-0.050	-0.137*	-0.183*	***-0.168****
t-stat	-3.295	-0.561	-1.924	-2.692	-2.444
Italy	-0.200	***-0.202***	-0.238*	-0.169*	-0.078
t-stat	-3.139	-1.471	-2.502	-1.778	-0.838
Japan	-0.219*	***-0.259****	-0.138*	-0.154*	-0.153*
t-stat	-4.494	-3.102	-1.940	-2.258	-2.382
Mexico	-0.589*	-0.546*	***-0.606****	-0.529*	-0.567*
t-stat	-6.353	-3.761	-4.532	-3.798	-4.256
Netherlands	-0.100	***-0.089***	-0.061	-0.026	-0.035
t-stat	-2.256	-0.893	-0.817	-0.361	-0.555
New Zealand	-0.426*	-0.313*	***-0.441****	-0.177	-0.446*
t-stat	-3.741	-2.212	-3.138	-0.994	-3.471
Norway	-0.133	-0.081	-0.171*	***-0.106***	-0.077
t-stat	-2.768	-0.721	-2.087	-1.232	-0.893
Spain	-0.096	-0.172	-0.202*	***-0.118***	-0.055
t-stat	-2.341	-1.482	-2.047	-1.203	-0.635
Sweden	-0.186	0.221	-0.068	-0.093	***-0.114***
t-stat	-2.663	0.888	-0.631	-0.930	-1.120
Switzerland	-0.108	0.164	***-0.074***	-0.002	-0.024
t-stat	-1.877	0.952	-0.815	-0.020	-0.285
UK	-0.118	NA	***-0.106***	-0.043	-0.051
t-stat	-2.102		-0.863	-0.386	-0.537

*significant at the 5% level. Italicized coefficients in bold font are for the equation with the minimum sum of the squared residuals among the four estimations with instruments. NA-not applicable due to the number of lags in the IV estimation.

$\Delta f_t = d_{11} + \delta_1\left(f_{t-1} - \alpha - \beta p_{t-1}^{US}\right) + \phi \Delta p_t^{US} + \nu_t$ Without instruments

$\Delta f_t = d_{11} + \delta_1 w_t + \phi \Delta p_t^{US} + \nu_t$ With instrument

$w_t = \left(f_{t-1} - \alpha - \beta' p_{t-1}^{US}\right) - \left(f_{t-m-1} - \alpha - \beta' p_{t-m-1}^{US}\right) m = 4,7,9,12$

As shown earlier, the error correction model of equation (5) can be rewritten as the autoregressive distributed lag (ADL) model of equation (6). As with the error correction model, there are indications of serial correlation in the initial estimations. The same procedure is employed as used to eliminate autocorrelation from the ECM specifications. Not surprisingly, given the derivation of the ADL form from the error correction model, the number of lags of Δf_t and/or Δp_t^{US} needed to eliminate serial correlation is the same for most countries (see Table 3).

Table 3-Lags and Variables Included to Eliminate Serial Correlation in the Autoregressive Distributed Lag Model

Country	Lags of Δf_t	Lags of Δp_t^{US}	p value of LM test in final specification
Argentina	0	0	.440
Australia	0	0	.299
Belgium	1	0	.210
Brazil	4	0	.164
Canada	2	1	.184
Chile	0	0	.527
Denmark	1	0	.521
Finland	1	0	.604
France	1	0	.216
Germany	0	0	.881
Italy	2	0	.295
Japan	1	0	.162
Mexico	1	0	.297
Netherlands	0	1	.156
New Zealand	1	0	.425
Norway	1	1	.804
Spain	0	1	.155
Sweden	1	0	.175
Switzerland	2	0	.172
UK	4	0	.372

Table 4 displays the estimated coefficient $\hat{\delta}_1$ and t-statistic on the lagged value of the country's dollar-denominated price level. Generally, the results are similar to the ECM estimations. The ten countries with significant coefficients on the error correction term in the standard specification plus Sweden also have significant coefficients in the ADL model. In the ADL versions using the instrument the $\hat{\delta}_1$ are significant for ten countries in at least three of the four IV specifications. Nine of these ten countries are the same as in the ECM model with instruments. Sweden is the only country for which results are distinctly different in the ECM and ADL models with instruments. In the estimations for the error correction model with instruments, there is not a single significant coefficient among the 4 different IV for Sweden while in the ADL version with instruments, each IV has a significant coefficient.

Again, it is disconcerting to find results dependent on the value of m. However, when considering just the results from the IV specification that minimizes the sum of the squared residuals, there is more support for PPP. Fourteen of the twenty countries display significant coefficients in the model with the instrument that minimizes the SSR. In contrast to the ECM results, a specification with m = 12 minimizes the SSR for eleven countries, more than twice as often as any other version. More positively, the different results when using different instruments may indicate that the IV test for cointegration has low power when a suboptimal instrument is used, at least when applied to the Taylor data. It appears that additional work is needed to establish criteria for the optimal selection of m in the ILE test.

Table 4-Estimation of δ_1 in ADL Model, Without and With Instruments

		Instrumental Variables			
Country	ADL MODEL	m = 4	m = 7	m = 9	m = 12
Argentina	-0.365*	-0.503*	-0.183	-0.236*	***-0.383****
t-stat	-4.881	-4.065	-1.534	-2.418	-3.927
Australia	-0.147	-0.128	-0.130	-0.124	***-0.125***
t-stat	-2.328	-0.947	-1.097	-1.087	-1.145
Belgium	-0.503*	***-0.492****	-0.369*	-0.385*	-0.439*
t-stat	-5.391	-3.452	-2.958	-2.892	-2.845
Brazil	-0.170	NA	-0.260*	***-0.168****	-0.104
t-stat	-3.068		-2.193	-1.733	-1.257
Canada	-0.219*	NA	-0.096	-0.131*	***-0.250****
t-stat	-3.716		-1.123	-1.676	-3.293
Chile	-0.281*	-0.261*	-0.239*	-0.305*	***-0.305****
t-stat	-3.512	-2.045	-2.212	-2.791	-2.714
Denmark	-0.182*	-0.089	***-0.215****	-0.178*	-0.166*
t-stat	-3.367	-0.943	-2.673	-2.098	-2.006
Finland	-0.627*	***-0.632****	-0.618*	-0.675*	-0.647*
t-stat	-8.099	-5.805	-5.559	-5.678	-5.179
France	-0.195	-0.249*	-0.260*	***-0.258****	-0.082
t-stat	-3.103	-1.799	-1.942	-1.802	-0.545
Germany	-0.171*	-0.036	-0.137*	-0.181*	***-0.168****
t-stat	-3.313	-0.395	-1.942	-2.671	-2.433
Italy	-0.197	NA	-0.265*	***-0.191****	-0.100
t-stat	-3.064		-2.725	-1.923	-1.023
Japan	-0.229*	-0.240*	-0.151*	-0.161*	***-0.177****
t-stat	-4.653	-3.211	-2.336	-2.483	-2.794
Mexico	-0.589*	-0.535*	-0.589*	-0.498*	***-0.550****
t-stat	-6.309	-3.532	-4.104	-3.319	-3.970
Netherlands	-0.061	0.027	***0.001***	0.036	0.004
t-stat	-1.402	0.305	0.018	0.508	0.065
New Zealand	-0.432*	-0.275	-0.475*	-0.199	***-0.488****
t-stat	-3.727	-1.569	-2.826	-0.869	-3.332
Norway	-0.131	-0.141	-0.200*	***-0.118***	-0.092
t-stat	-2.620	-1.382	-2.307	-1.241	-0.935
Spain	-0.071	-0.063	-0.156	***-0.075***	-0.010
t-stat	-1.715	-0.553	-1.565	-0.773	-0.114
Sweden	-0.279*	-0.289*	-0.280*	-0.279*	***-0.294****
t-stat	-4.221	-2.577	-3.114	-3.052	-3.045
Switzerland	-0.110	NA	-0.146	-0.061	***-0.078***
t-stat	-1.888		-1.367	-0.596	-0.823
UK	-0.107	NA	-0.185	-0.054	***-0.055***
t-stat	-1.869		-1.106	-0.427	-0.526

*significant at the 5% level, critical values for the ADL Model column were obtained from Banerjee, Dolado, and Mestre (1998). Italicized coefficients in bold font are for the equation with the minimum sum of the squared residuals among the four estimations with instruments.

$\Delta f_t = d'_{11} + \delta_1 f_{t-1} + \gamma p_{t-1}^{US} + \phi' \Delta p_t^{US} + \nu_t$ Without instruments

$\Delta f_t = d'_{11} + \delta_1 w_{1t} + \gamma w_{2t} + \phi' \Delta p_t^{US} + \nu_t$ With instruments

$w_t = (w_{1t}, w_{2t}) = \left[\left(f_{t-1} - f_{t-m-1} \right), \left(p_{t-1}^{US} - p_{t-m-1}^{US} \right) \right]$ m = 4,7,9,12

Finally, Table 5 displays the t-statistics for the estimated δ_1 from the second step of the Engle-Granger (EG) procedure shown in equation (7) compared to those derived from the EG approach with instruments replacing the estimated residuals, $\left(f_{t-1} - \hat{\alpha} - \hat{\beta}p_{t-1}^{US}\right)$. Failure to reject the null indicates the presence of a unit root in the estimated equation, that is, nonstationary residuals implying the absence of a cointegrating relation between the dollar-denominated foreign price level and the US price level over the sample period. Simply stated, failure to reject the null would signal failure to support PPP. The Schwarz criterion determines lag length in the unit root tests applied to the estimate residuals with the same lag lengths imposed in the IV estimations.

As results in Table 5 show, unit root tests applied to the estimated errors residuals from equation (7) for each country reject the null at the 5% level in twelve instances, reflecting just slightly more evidence of PPP than the traditional ECM and ADL models. The IV estimations show substantial evidence of PPP, although once again conclusions can change with the choice of instrument. In sixteen of the twenty countries, at least three of the four IV specifications have significant coefficients, that is the null hypothesis of nonstationary residuals is rejected, evidence supportive of PPP. Indeed, in eighteen instances the specification with m = 12 supports PPP. Considering just the results from the IV estimation that minimizes the SSR for each country also indicates strong evidence of PPP, a significant coefficient appears in seventeen of twenty cases. Again, there is some evidence of sensitivity to the choice of instrument. Taking two examples, in the case of Argentina the t-stat ranges from -4.135 to -1.514 while for Germany the t-stats vary from -2.123 to -.287.

Table 5 t-Statistics on Estimated δ_1 from Equation 7, Without and With Instruments.

				Instruments			
Country	Lags	No obs.	Unit Root Test	m = 4	m = 7	m = 9	m=12
Argentina	0	110	-4.882*	-4.114*	-1.514	-2.538*	***-4.135****
Australia	0	125	-2.732	-1.473	-1.611	***-1.656****	-1.778*
Belgium	1	115	-5.464*	***-3.386****	-3.188*	-3.218*	-3.340*
Brazil	0	106	-2.642	.346	***-1.602***	-1.231	-1.166
Canada	0	125	-3.040	.667	-.612	-1.369	***-3.343****
Chile	0	82	-1.685	-1.596	***-1.747****	-2.292*	-2.283*
Denmark	1	115	-3.930*	-1.123	-3.202*	-2.454*	***-2.581****
Finland	1	114	-6.229*	-4.278*	-4.222*	***-4.316****	-3.407*
France	1	115	-4.433*	-3.010*	-3.377*	-3.415*	***-2.697****
Germany	0	115	-3.210	-.287	-1.654*	***-2.123****	-2.044*
Italy	1	115	-3.973*	-1.565	***-2.764****	-2.399*	-1.631
Japan	1	111	-5.093*	***-3.767****	-2.818*	-2.885*	-3.078*
Mexico	1	109	-6.627*	-4.007*	***-4.671****	-3.837*	-4.177*
Netherlands	1	125	-3.781	***-1.863****	-1.683*	-1.554	-1.907*
New Zealand	1	47	-4.213*	-2.620*	***-3.480****	-1.379	-3.729*
Norway	1	125	-4.119*	-2.079*	-3.103*	***-2.492****	-2.477*
Spain	1	115	-3.203	-2.890*	-2.308*	-2.300*	***-2.070****
Sweden	1	115	-4.382*	-1.923*	-2.499*	-2.490*	-2.635*
Switzerland	1	103	-4.249*	***-2.204****	-2.944*	-1.842*	-2.512*
UK	0	125	-3.056	***-1.538***	-2.511*	-1.666*	-1.883*

Schwarz criterion used to determine lag length. *significant at the 5% level. Critical values for the test statistic displayed in the unit root test column are from Table C, page 441 of Enders (2004). Italicized t statistics in bold font are from the equation with the minimum sum of the squared residuals among the four estimations with instruments.

Conclusions

The ECM and ADL model, with or without instrumental variables, and the traditional EG two-step approach provide some support for the PPP hypothesis, evidence broadly consistent with that from earlier studies using the Taylor data. The strongest evidence in favor of PPP is from the Engle-Granger procedure with instruments. Using the criterion of selecting the m which minimizes the SSR, seventeen of the twenty countries in the sample show results supportive of PPP. Conclusions from the EG method with instruments are similar to Taylor's original findings.

How does the ILE instrumental variable test for cointegration compare to traditional methods? The ILE approach certainly simplifies single equation cointegration tests in that the asymptotic properties of the t statistics are standard normal. But, unlike the findings of ILE in their application of the test to money demand in the UK, when instruments are used in the well-known single equation cointegration tests the results are sometimes not robust with respect to choice of instrument, at least when applied to Taylor's data on exchange rates and price levels. This suggests that an important addition to the test would be the development of criteria for the optimal selection of the instrument.

Appendix A-Countries and Period Coverage

Country	Taylor data-years of coverage	Updated to
Argentina	1884-1996	2006
Australia	1870-1996	2007
Belgium	1870-1996	2007
Brazil	1880-1996	2007
Canada	1870-1996	2007
Denmark	1880-1996	2007
Finland	1881-1996	2007
France	1880-1996	2007
Germany	1880-1996	2007
Italy	1880-1996	2007
Japan	1885-1996	2007
Mexico	1886-1996	2007
Netherlands	1870-1996	2007
Norway	1870-1996	2007
Portugal	1890-1996	2007
Spain	1880-1996	2007
Sweden	1880-1996	2007
Switzerland	1892-1996	2007
UK	1850-1996	2007
US	1870-1996	2007
Additional countries in the data set but for which results are not reported in Taylor (2002)		
Chile	1913-1996	2007
Greece	1948-1996	2007
New Zealand	1948-1996	2007

Appendix B-Unit Root Tests

B-1Unit Root Tests on the Nominal Exchange Rate

Unit root tests	ADF Null-unit root in level		DF-GLS Null-unit root in level		KPSS Null-stationary	
Country	Const,t	Const	Const,t	Const	Const,t	Const
Argentina	-0.819	1.350	-0.526	1.854	0.295*	0.965*
Australia	-2.407	0.512	-2.348	1.378	0.220*	1.411*
Belgium	-0.982	-1.561	-1.245	-0.464	0.270*	1.058*
Brazil	-1.384	0.179	-1.246	0.436	0.273*	0.908*
Canada	-3.062	-2.416	-3.036*	-1.322	0.198*	0.977*
Denmark	-4.262*	-1.996	-4.205*	-1.254	0.178*	1.196*
Finland	-1.698	-1.042	-1.791	0.343	0.196*	1.295*
France	-1.196	-0.926	-1.301	0.377	0.182*	1.282*
Germany	-2.193	-1.920	-2.248	-0.806	0.262*	1.010*
Italy	-2.390	-0.736	-1.735	0.394	0.130*	1.295*
Japan	-2.079	-1.242	-2.146	-0.313	0.158*	1.069*
Mexico	-0.993	0.974	-0.774	2.020	0.266*	1.031*
Netherlands	-2.584	-2.573	-2.493	-2.366*	0.146*	0.143
Norway	-4.157*	-2.407	-4.183*	-1.377	0.080	1.270*
Portugal	-2.280	-1.188	-2.333	0.144	0.134*	1.109*
Spain	-2.415	-0.600	-1.937	0.492	0.193*	1.311*
Sweden	-4.728*	-1.478	-3.106*	-1.002	0.221*	1.155*
Switzerland	-2.070	0.022	-1.556	0.580	0.260*	1.052*
UK	-2.600	-0.907	-2.097	-0.324	0.299*	1.294*
US	na	na	na	na	na	na
Additional countries						
Chile	-2.082	-0.319	-1.538	0.439	0.222*	1.207*
Greece	-2.731	-2.425	-1.825	0.192	0.114	0.912*
New Zealand	-2.377	-1.296	-2.569	-0.590	0.112	0.859*

Note: Schwarz criterion used to select lag length in the ADF, DF-GLS tests.

* Significant at 5%

B-2 Unit Root Tests on the Price Level

Unit root tests	ADF Null-unit root in level		DF-GLS Null-unit root in level		KPSS Null-stationary	
Country	Const,t	Const	Const,t	Const	Const,t	Const
Argentina	-1.235	0.449	-1.492	-0.031	0.298*	0.987*
Australia	-1.591	1.308	-0.952	1.226	0.347*	1.328*
Belgium	-3.139	-0.091	-1.780	1.439	0.139*	1.440*
Brazil	-1.255	0.493	-1.257	0.632	0.277*	0.945*
Canada	-1.729	1.281	-0.825	2.270	0.317*	1.326*
Denmark	-2.234	0.591	-1.106	1.326	0.290*	1.297*
Finland	-2.872	-0.252	-1.984	1.364	0.095	1.343*
France	-3.262*	-0.830	-2.395	0.015	0.153*	1.342*
Germany	-1.565	-1.308	-1.659	-0.169	0.230*	1.086*
Italy	-3.036	-0.175	-2.041	0.948	0.164*	1.330*
Japan	-2.371	-1.126	-2.344	0.013	0.134*	1.254*
Mexico	-0.951	0.985	-0.792	1.542	0.284*	1.085*
Netherlands	-1.919	0.962	-0.834	1.831	0.324*	1.341*
Norway	-2.112	0.296	-1.418	1.254	0.293*	1.353*
Portugal	-3.662*	-0.772	-3.381*	0.180	0.101	1.193*
Spain	-2.377	1.072	-0.922	2.037	0.317*	1.307*
Sweden	-2.006	0.662	-1.049	1.618	0.294*	1.285*
Switzerland	-2.556	-0.187	-2.129	1.286	0.186*	1.203*
UK	-1.806	0.864	-0.906	1.510	0.331*	1.302*
US	-2.029	1.177	-0.695	1.665	0.324*	1.323*
Additional countries						
Chile	-1.969	0.045	-1.292	0.401	0.228*	1.216*
Greece	-2.466	-0.336	-2.174	0.005	0.173*	0.924*
New Zealand	-4.550*	-1.160	-4.245*	-0.313	0.121*	0.936*

Note: Schwarz criterion used to select lag length in the ADF, DF-GLS tests.
* Significant at 5%

B-3 Unit Root Tests on the Dollar-denominated Price Level

Unit root tests	ADF Null-unit root in level		DF-GLS Null-unit root in level		KPSS Null-stationary	
Country	Const,t	Const	Const,t	Const	Const,t	Const
Argentina	-3.821*	-1.420	-3.338*	-0.928	0.268*	1.121*
Australia	-1.999	-0.419	-1.369	0.154	0.333*	1.230*
Belgium	-3.466*	-0.085	-2.727*	0.766	0.283*	1.269*
Brazil	-2.226	-0.378	-2.218	0.613	0.206*	1.132*
Canada	-1.637	1.581	-0.640	2.484	0.316*	1.343*
Denmark	-1.667	1.322	-0.774	2.554	0.301*	1.237*
Finland	-2.745	-0.108	-2.027	0.741	0.265*	1.248*
France	-1.629	1.130	-0.801	1.876	0.305*	1.197*
Germany	-3.398*	-2.899*	-3.267*	-2.891*	0.096	0.606*
Italy	-2.238	0.484	-1.472	1.405	0.299*	1.265*
Japan	-3.045	-0.689	-2.618	0.350	0.222*	1.231*
Mexico	-4.115*	-0.573	-2.527	-0.019	0.275*	1.167*
Netherlands	-1.842	1.168	-0.817	1.827	0.326*	1.273*
Norway	-2.058	0.366	-1.433	1.109	0.301*	1.284*
Portugal	-1.195	1.146	-0.723	1.850	0.303*	1.093*
Spain	-1.924	0.391	-1.351	0.964	0.287*	1.143*
Sweden	-2.264	0.554	-1.382	1.741	0.259*	1.283*
Switzerland	-1.751	0.385	-1.327	1.856	0.247*	1.175*
UK	-1.282	1.757	-0.439	2.806	0.310*	1.272*
US	na	na	na	na	na	na
Additional countries						
Chile	-3.797*	-2.980*	-3.840*	-2.349*	0.080	0.679*
Greece	-7.341*	0.603	-0.739	-0.109	0.174*	0.857*
New Zealand	-2.919	0.215	-2.614	0.470	0.112	0.951*

Note: Schwarz criterion used to select lag length in the ADF, DF-GLS tests.
* Significant at 5%

B-4 Tests for a Second Unit Root in the Nominal Exchange Rate

Unit root tests	ADF Null-2nd unit root		DF-GLS Null-2nd unit root		KPSS Null-stationary 1st dif.	
Country	Const,t	Const	Const,t	Const	Const,t	Const
Argentina	-6.678*	-6.115*	-6.364*	-6.131*	0.098	0.573*
Australia	-6.424*	-6.394*	-4.099*	-5.954*	0.072	0.269
Belgium	-7.872*	-7.774*	-3.537*	-2.499*	0.112	0.227
Brazil	-3.802*	-3.507*	-3.746*	-3.480*	0.077	0.471*
Canada	-8.952*	-8.955*	-8.474*	-7.648*	0.062	0.081
Denmark	-9.794*	-9.809*	-9.751*	-9.835*	0.035	0.056
Finland	-7.541*	-7.543*	-7.474*	-7.312*	0.121*	0.159
France	-6.734*	-6.733*	-6.681*	-6.560*	0.175*	0.199
Germany	-2.806	-2.708*	-2.714*	-2.664*	0.088	0.190
Italy	-7.310*	-7.341*	-7.130*	-4.513*	0.101	0.101
Japan	-5.238*	-5.236*	-5.280*	-5.253*	0.115	0.144
Mexico	-9.656*	-9.477*	-9.641*	-9.511*	0.068	0.396*
Netherlands	-8.360*	-8.335*	-8.354*	-8.168*	0.046	0.123
Norway	-8.807*	-8.823*	-8.753*	-8.816*	0.028	0.041
Portugal	-5.875*	-5.886*	-5.691*	-5.090*	0.061	0.091
Spain	-7.700*	-7.732*	-7.700*	-7.659*	0.132*	0.136
Sweden	-9.609*	-9.643*	-9.523*	-9.601*	0.080	0.096
Switzerland	-8.409*	-8.368*	-8.285*	-7.350*	0.047	0.186
UK	-11.015*	-11.053*	-10.954*	-11.012*	0.129*	0.147
US	na	na	na	na	na	na
Additional countries						
Chile	-3.615*	-3.632*	-3.646*	-3.458*	0.185*	0.256
Greece	-7.272*	-7.008*	-7.157*	-6.753*	0.106*	0.189
New Zealand	-6.448*	-6.505*	-4.213*	-2.549*	0.065	0.143

Note: Schwarz criterion used to select lag length in the ADF, DF-GLS tests.
* Significant at 5%

B-5 Tests for a Second Unit Root in the Price Level

Unit root tests	ADF Null-2nd unit root		DF-GLS Null-2nd unit root		KPSS Null-stationary 1st dif.	
Country	Const,t	Const	Const,t	Const	Const,t	Const
Argentina	-3.572*	-3.183*	-3.460*	-3.170*	0.091	0.546*
Australia	-5.459*	-3.456*	-5.448*	-2.558*	0.072	0.657*
Belgium	-9.847*	-9.865*	-9.917*	-9.848*	0.111	0.142
Brazil	-3.455*	-2.956*	-3.239*	-2.960*	0.075	0.490*
Canada	-6.787*	-6.379*	-6.527*	-6.365*	0.062	0.504*
Denmark	-4.374*	-4.153*	-3.798*	-3.435*	0.074	0.348*
Finland	-6.810*	-6.832*	-6.861*	-6.852*	0.099	0.105
France	-2.915	-2.971*	-2.388	-2.034*	0.150*	0.175
Germany	-9.089*	-9.094*	-9.117*	-9.087*	0.081	0.132
Italy	-5.493*	-5.483*	-5.532*	-5.432*	0.100	0.148
Japan	-3.573*	-3.575*	-3.373*	-3.065*	0.114	0.116
Mexico	-4.730*	-4.385*	-4.602*	-3.094*	0.074	0.531*
Netherlands	-6.787*	-6.510*	-6.607*	-4.924*	0.085	0.471*
Norway	-5.574*	-5.463*	-5.596*	-5.067*	0.049	0.277
Portugal	-2.545	-2.577	-2.566	-2.455*	0.059	0.079
Spain	-5.798*	-5.459*	-5.825*	-4.947*	0.124*	0.543*
Sweden	-5.377*	-5.162*	-5.161*	-5.070*	0.065	0.353*
Switzerland	-5.822*	-5.833*	-5.599*	-4.726*	0.050	0.090
UK	-5.255*	-4.860*	-5.120*	-4.871*	0.070	0.521*
US	-5.985*	-5.523*	-5.507*	-3.326*	0.066	0.671*
Additional countries						
Chile	-4.278*	-4.250*	-4.316*	-4.064*	0.168*	0.247
Greece	-2.071	-2.073	-2.011	-1.876*	0.176*	0.208
New Zealand	-2.382	-2.334	-2.229	-2.071	0.192*	0.198

Note: Schwarz criterion used to select lag length in the ADF, DF-GLS tests.
* Significant at 5%

B-6 Tests for a Second Unit Root in the Dollar-denominated Price Level

Unit root tests	ADF Null-2nd unit root		DF-GLS Null-2nd unit root		KPSS Null-stationary 1st dif.	
Country	Const,t	Const	Const,t	Const	Const,t	Const
Argentina	-8.687*	-8.682*	-12.233*	-11.631*	0.176*	0.262
Australia	-5.943*	-6.114*	-4.026*	-4.935*	0.115	0.170
Belgium	-8.839*	-8.793*	-8.277*	-8.149*	0.057	0.196
Brazil	-9.754*	-9.746*	-9.666*	-9.451*	0.033	0.097
Canada	-8.190*	-7.712*	-8.221*	-7.493*	0.042	0.614
Denmark	-9.480*	-9.233*	-9.496*	-9.253*	0.040	0.415*
Finland	-9.469*	-9.438*	-9.336*	-8.444*	0.148*	0.306
France	-8.944*	-8.607*	-8.923*	-8.292*	0.046	0.420*
Germany	-10.592*	-10.631*	-10.677*	-10.671*	0.025	0.031
Italy	-9.879*	-9.786*	-9.947*	-9.693*	0.043	0.319
Japan	-6.450*	-6.478*	-5.858*	-4.575*	0.045	0.095
Mexico	-11.108*	-11.092*	-10.806*	-9.300*	0.120*	0.316
Netherlands	-8.781*	-8.378*	-8.070*	-7.567*	0.047	0.659*
Norway	-7.674*	-7.532*	-7.725*	-7.393*	0.034	0.350*
Portugal	-8.417*	-8.102*	-7.249*	-1.385	0.500*	0.354*
Spain	-7.898*	-7.726*	-7.947*	-7.652*	0.056	0.419*
Sweden	-8.352*	-8.232*	-8.360*	-8.265*	0.040	0.195
Switzerland	-7.461*	-7.409*	-6.198*	-4.514*	0.052	0.201
UK	-9.939*	-9.555*	-9.778*	-9.554*	0.045	0.559*
US	na	na	na	na	na	na
Additional countries						
Chile	-11.407*	-11.463*	-11.531*	-11.526*	0.082	0.096
Greece	-8.340*	-8.259*	-8.451*	-7.447*	0.135*	0.391*
New Zealand	-6.673*	-6.761*	-4.127*	-2.482*	0.081	0.124

Note: Schwarz criterion used to select lag length in the ADF, DF-GLS tests.
* Significant at 5%

B-7 Conclusions from Unit Root Tests

Unit root tests	Nominal Exchange Rate			Price Level			Dollar-denominated Price Level		
Country	Level	1st dif	I(?)	Level	1st dif	I(?)	Level	1st dif	I(?)
Argentina	UR	S	I(1)	UR	S	I(1)	?	S	?
Australia	UR	S	I(1)	UR	S	I(1)	UR	S	I(1)
Belgium	UR	S	I(1)	UR	S	I(1)	?	S	?
Brazil	UR	S	I(1)	UR	S	I(1)	UR	S	I(1)
Canada	UR	S	I(1)	UR	S	I(1)	UR	S	I(1)
Denmark	?	S	?	UR	S	I(1)	UR	S	I(1)
Finland	UR	S	I(1)	UR	S	I(1)	UR	S	I(1)
France	UR	S	I(1)	UR	?	?	UR	S	I(1)
Germany	UR	S	I(1)	UR	S	I(1)	S	S	S
Italy	UR	S	I(1)	UR	S	I(1)	UR	S	I(1)
Japan	UR	S	I(1)	UR	S	I(1)	UR	S	I(1)
Mexico	UR	S	I(1)	UR	S	I(1)	UR	S	I(1)
Netherlands	?	S	?	UR	S	I(1)	UR	S	I(1)
Norway	?	S	?	UR	S	I(1)	UR	S	I(1)
Portugal	UR	S	I(1)	?	?	?	UR	?	?
Spain	UR	S	I(1)	UR	?	?	UR	S	I(1)
Sweden	?	S	?	UR	S	I(1)	UR	S	I(1)
Switzerland	UR	S	I(1)	UR	S	I(1)	UR	S	I(1)
UK	UR	S	I(1)	UR	S	I(1)	UR	S	I(1)
US	NA	NA	NA	UR	S	I(1)	NA	NA	NA
Additional Countries									
Chile	UR	S	I(1)	UR	S	I(1)	S	S	S
Greece	UR	S	I(1)	UR	UR	I(2)	UR	?	?
New Zealand	UR	S	I(1)	?	UR	?	UR	S	I(1)

+ In fact, the results actually suggest that the logged price level has *at least* two unit roots. No tests were conducted to check for additional orders of integration.
UR-unit root, S-stationary, NA-not applicable

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