

Why Are Real Interest Rates Not Equalized Internationally?

S. Young Chung
Korea Insurance Development Institute (KIDI)
KFPA Bldg. 35-4
Yoido-Dong, Youngdeungpo-Gu
Seoul, Korea
sychung100@hananet.net

William J. Crowder¹
Department of Economics
Box 19479
University of Texas at Arlington
Arlington, TX 76019
(817) 272-3147
crowder@uta.edu

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¹Corresponding author.

Abstract

This study examines the parity conditions underlying real interest parity in order to determine why real rates are not equalized internationally. Our results for 7ve countries reject conclusively this set of necessary conditions. This implies that RIP does not hold between these economies. Our results tell us that no single parity condition can explain the failure of RIP in all cases. But it does appear that the Fisher relation is the least likely to violate the RIP equilibrium. On the other hand UIP appears to be the most commonly violated of the four with EAPPP lying somewhere between these.

1 Introduction

International financial economists are intensely concerned with several parity conditions that relate goods prices and asset returns across countries. These include purchasing power parity (PPP) and its variants and interest rate parity (IRP) and its variants. Each of these parity conditions measures a degree of integration between the economies of the world. The greater the economic integration across countries, the greater the likelihood that the more restrictive of these parity conditions will have empirical support. For example, the strict PPP hypothesis implies that aggregate price levels will be equal in terms of a common currency. This condition is very stringent since it does not allow for even temporary deviations from the equilibrium condition.¹ A less restrictive version is long-run PPP where price levels, measured in a common currency, across countries converge over some period of time, maybe a very long period of time. Recognizing all of the impediments that keep strict PPP from holding, economists have put their efforts in studying the long-run version of this equilibrium condition.

In this study we are concerned with real interest rate parity (RIP). We are not only interested in testing its validity, which we show does not hold empirically, but in trying to discover why RIP does not characterize international capital markets. And by doing so, we hope to shed some light on a few other international parity conditions.

It is well understood that RIP can only hold when uncovered interest parity (UIP), ex-ante PPP (EAPPP) and the Fisher relation in each country are all simultaneously true. These four equilibrium or parity conditions, i.e., UIP, EAPPP and two Fisher relations, represent necessary conditions for RIP but are not sufficient to ensure that real rates are equal internationally. What is less widely recognized is that these four parity conditions holding simultaneously have important implications for the time series properties of the underlying variables. Specifically, for RIP to be true, the nominal interest rates and inflation rates in all countries must be stationary. So a simple test of the necessary conditions for RIP is a test for the stationarity of these variables. This is achieved by using the method recently proposed by Taylor and Sarno (1998) in the context of PPP.

Our results for 7ve countries reject conclusively this set of necessary con-

¹Presumably goods arbitrage will be instantaneous in such a world preventing price levels from diverging.

ditions. This implies that RIP does not hold between these economies. But we extend the analysis to determine which of the parity conditions may be failing resulting in the violation of RIP. Our results tell us that no single parity condition can explain the failure of RIP in all cases. But it does appear that the Fisher relation is the least likely to violate the RIP equilibrium. On the other hand UIP appears to be the most commonly violated of the four with EAPPP lying somewhere between these.

The rest of the paper is organized as follows: section 2 discusses the theoretical conditions necessary for RIP and the time series implications of these conditions. Section 3 describes the econometric methodology and discusses the various hypothesis tests. Section 4 presents the empirical results and section 5 concludes.

2 Theoretical Model

Real interest parity (RIP) is the condition where real rates of return on essentially identical assets are equalized across countries. There are many reasons why real interest rates will not always be equal across countries, i.e., country-specific risk, transactions costs, information asymmetries, differential tax treatment, etc., so our focus is on long-run RIP.

Define $r_{j;t}$ to be the real rate of interest on assets of country j in time period t : The RIP condition given in equation (1)

$$r_{j;t} = r_{i;t} \quad (1)$$

where $i \in j$. It has been established by Rose (1989), Crowder and Ho®man (1996) and others that theoretically the real rate should be proportional to consumption growth implying that the two will share basic time series properties. Of these, the most important for our purposes is the result that, since consumption growth is a covariance stationary process, so should be the real interest rate.

Now the real interest rate in country j can be defined by the simple Fisher relationship given in equation (2),

$$r_{j;t} = i_{j;t} - \pi_{j;t+k} \quad (2)$$

where $i_{j;t}$ is the nominal interest rate on the asset of country j in period t , $\pi_{j;t+k}$ is the ex-post inflation in country j over the holding period k of

the asset and $\epsilon_{j,t+k}$ represents the rational expectations error associated with agents forecast of inflation. Since $\epsilon_{j,t+k}$ is a white noise process by assumption and $r_{j,t}$ is stationary, if $i_{j,t}$ and $\mu_{j,t+k}$ are I(1) processes, they must be co-integrated for equation (2) to hold empirically.² It is important to recognize that since $\epsilon_{j,t+k}$ cannot be observed that $r_{j,t}$ is also unobservable. Therefore testing the condition in equation (1) must be done indirectly by examining the observable variables $i_{j,t}$ and $\mu_{j,t+k}$:

Nominal interest rates across countries are related via the UIP relationship. UIP relates the nominal interest rate differential to the (expected) exchange rate depreciation as in equation (3)

$$i_{j,t} - i_{i,t} = \Phi s_{t+k} + e_{t+k} \quad (3)$$

where s_{t+k} is the log of the spot exchange rate in period $t + k$, e_{t+k} is the rational expectations error associated with agents forecast of s_{t+k} and Φ is the first difference operator. If nominal interest rates are first order integrated or I(1), then equation (3) implies that the two nominal rates are co-integrated since Φs_{t+k} and e_{t+k} are stationary or I(0).

Inflation rates are related across economies via the EAPPP relationship. EAPPP relates the inflation differential to the (expected) exchange rate depreciation as in equation (4)

$$\mu_{j,t+k} - \mu_{i,t+k} = \Phi s_{t+k} + \epsilon_{t+k}^2 \quad (4)$$

where ϵ_{t+k}^2 is the combined rational expectations forecast errors associated with agents forecast of future inflation and exchange rates. Again, if $\mu_{j,t+k}$ and $\mu_{i,t+k}$ are both I(1) variables then they must be co-integrated under the assumption of rational expectations.

Combining equations (2), (3) and (4) results in the basic RIP equilibrium condition as in equation (1) and equation (5).

$$i_{j,t} - i_{i,t} = \mu_{j,t+k} - \mu_{i,t+k} + (\epsilon_{j,t+k} - \epsilon_{i,t+k}) \quad r_{j,t} = r_{i,t} \quad (5)$$

In order to demonstrate the joint time series behavior of the observable variables, $i_{j,t}$; $i_{i,t}$; $\mu_{j,t+k}$; and $\mu_{i,t+k}$ it is convenient to use a vector autoregressive (VAR) model as in equation (6),

²This result has been exploited by Mishkin (1992), Crowder and Hoffman (1996) and Crowder (1998).

$$\phi(L)X_t = \alpha_t + u_t \quad (6)$$

where X_t is the 4x1 vector of observable variables, $i_{j,t}$; $i_{i,t}$; $\frac{1}{2}j_{t+k}$; and $\frac{1}{4}i_{t+k}$; $\phi(L)$ is a p^{th} -order matrix polynomial in the lag operator, α_t is a vector of deterministic components and u_t is a vector of white noise error terms. Equation (6) can be rewritten in error-correction model form as in equation (7),

$$\phi X_t = \alpha_t + \beta X_{t-1} + \sum_{i=1}^{p-1} \phi_i X_{t-i} + u_t \quad (7)$$

where the long-run impact matrix β is of particular interest. There are three possibilities with respect to the rank of the β matrix; 1) β is of zero rank implying that all of the variables in X_t are I(1) and not cointegrated, 2) β is of reduced rank implying that at least some of the variables in X_t are integrated, and 3) β is of full rank implying that all of the variables in X_t are stationary in levels. Estimation of (7) that results in either of the first two conditions on β implies a violation of the necessary conditions for RIP. Equations (2), (3) and (4) imply the following representation for βX_{t-1} :³

$$\begin{matrix} 2 & 1 & 0 & i & 1 & 0 & 3 & 2 & i_{j,t} & 3 \\ 6 & 0 & 1 & 0 & i & 1 & 7 & 6 & i_{i,t} & 7 \\ 8 & 0 & 0 & 1 & i & 1 & 5 & 4 & \frac{1}{2}j_{t+k} & 5 \\ 4 & 1 & i & 1 & 0 & 0 & & & \frac{1}{4}i_{t+k} & \end{matrix} \quad (8)$$

From (8) it can be seen that β is of full rank when the necessary conditions for RIP hold, implying that all of the variables in X_t are stationary in levels. In other words, the four equilibrium relationships necessary for RIP to hold imply that the underlying observable variables in the relationship must be stationary. Thus a simple test for the necessary condition for RIP is simply to test each of the individual series for a unit root. If any one is found to be non-stationary, RIP cannot hold empirically since this would be violating at least one of the four equilibrium relationships.

It is possible though that only some of the necessary equilibrium relationships are violated while others continue to be true. By analyzing each

³ β can be decomposed into two matrices $\beta = \alpha \gamma'$ where α represent the co-integrating relationships among X_t : If β has zero rank then α is the 4x4 null matrix and γ is the 4x4 identity matrix. If β is of reduced rank r ; then α and γ are both 4xr matrices. If β is of full rank then α can be written as 4x4 identity matrix.

of these relationships individually it is possible to shed light on the sources of RIP violations. In the next section we present the empirical methodology used to test the necessary conditions for RIP and those methods used to analyze the sources of the rejection of RIP.

3 Empirical Methodology

Since the joint stationarity of the variables is a necessary condition for RIP it would seem that a simple test of these conditions is to apply unit root tests to the individual variables. But it is well known that the power of such tests is notoriously weak when the autoregressive root is close to, but still less than, unity. Recently several researchers have proposed using a panel unit root testing approach that significantly increases the power of the test against the null.⁴ But Taylor and Sarno (1998) have shown that rejection of the null hypothesis in the panel unit root tests cannot be interpreted as stationarity of all the series in the panel. These tests are uninformative about the number of series that are stationary versus the number that are non-stationary. They suggest using Johansen's (1988, 1991) test for the number of cointegration vectors equal to the number of series in the VAR or whether the β matrix from estimation of (7) is of full rank.

Our strategy for the empirical analysis is straightforward. The first step is to test the rank of the β matrix from estimation of (7) for each of the country pairs. Once it has been established that we can reject the hypothesis that β is of full rank, we proceed to analyze the individual equilibrium conditions of UIP, EAPPP and the Fisher relation in each country, testing not only for an equilibrium between the germane variables but also testing the parameter restrictions implied by each of these parity conditions. We use Johansen's (1988, 1991) procedure throughout, to estimate and test both the rank of β and the individual parity conditions.

The Johansen procedure is based upon a p^{th} -order vector autoregressive (VAR) process transformed into error-correction model (VECM) form as in (7). The long-run multiplier matrix $\beta = -\alpha(1)$ can be decomposed into two $p \times r$ matrices such that $\beta = \alpha\gamma'$: The $p \times r$ matrix γ' represents the cointegrating vectors or the long-run equilibria of the system of equations. The $p \times r$ matrix α is the matrix of error-correction coefficients which mea-

⁴See Papell (1998) and the references therein for a discussion of the panel unit root tests as applied to the PPP hypothesis.

sure the rate each variable adjusts to the long-run equilibrium. Maximum likelihood estimation of (7) can be carried out by applying reduced rank regression. Johansen (1988, 1991) suggests first concentrating out the short-run dynamics by regressing ΦX_t and X_{t-1} on ΦX_{t-1} ; ΦX_{t-2} ; ..., ΦX_{t-k+1} and α_t and saving the residuals as R_{0t} and R_{1t} , respectively. Calculate the product moment matrices $S_{ij} = T^{-1} \sum_{t=1}^T R_{it} R_{jt}'$ and solve the eigenvalue problem $\begin{bmatrix} S_{11} & \dots & S_{1k} \\ \vdots & \ddots & \vdots \\ S_{k1} & \dots & S_{kk} \end{bmatrix} \begin{bmatrix} \lambda_1 \\ \vdots \\ \lambda_k \end{bmatrix} = 0$. The likelihood ratio statistic testing the rank of β is given by $\sum_{i=r+1}^k \ln(1 - \lambda_i)$ and is called the trace statistic by Johansen (1988, 1991).⁵ The distribution of this statistic is non-standard and depends upon, among other things, the specification of the deterministic components α_t in the VAR. If the series exhibit deterministic trends in the levels and non-zero means in the differences, then it will be appropriate to include a constant in α_t .⁶ If, however, the data are better characterized as having a non-zero mean in the levels and a zero mean in the first differences it will be appropriate to set $\alpha_t = 0$ and include a constant term in the X_t vector. The third possibility is that there are no statistically significant deterministic terms in the cointegration vectors implying that $\alpha_t = 0$ and the X_t vector will not contain a constant term.⁷

An examination of the data in figures 1 and 2 suggests that the appropriate characterization is to set $\alpha_t = 0$ and include a constant term in the X_t vector. This hypothesis can be formally tested using a LR test procedure discussed in Johansen (1994). We consider the hypothesis of $H_1^r(r)$; no trends in the data but a constant term in the cointegrating relation, versus $H_1(r)$; trends in the levels data. The form of the LR test is given in equation (9).

$$-2 \ln \left[\frac{L(H_1^r(r))}{L(H_1(r))} \right] = T \sum_{i=r+1}^k \ln \frac{1 - \lambda_i}{1 - \lambda_i^{\#}} \quad (9)$$

Note that the calculated test statistic depends on the value of r ; the number

⁵The trace test takes the null hypothesis of at least r cointegrating relationships in X_t versus the alternative of $r + 1$ cointegrating vectors.

⁶This is the only case considered by Taylor and Sarno (1998) because in this special case the limiting distribution of the trace statistic is $A^2(r)$:

⁷There are two other possible specifications for the deterministic components in the VAR. One entails including a trend in the VAR implying a quadratic trend in the data and the other includes a trend in the cointegrating vectors. Both of these specifications were rejected by the data using the proposed LR tests.

of cointegrating relations hypothesized. Johansen shows that this statistic has a \hat{A}^2 distribution with $p_j - r$ degrees of freedom. If we cannot reject this restriction, i.e., no trends in the levels data, we should test for the significance of the constant terms in various cointegrating relations since the trace test distribution will be different if this restriction is also true. This is a test of the hypothesis of $H_2(r)$; no trends in the data and no constant term in the cointegrating relation, versus $H_1^c(r)$; no trends in the levels data but a constant in the cointegration vectors. The form of this LR test is given in equation (10),

$$-2 \ln \left[\frac{L(H_2(r))}{L(H_1^c(r))} \right] = T \sum_{i=1}^r \ln \frac{1 - \lambda_{i+1}}{1 - \lambda_i} \quad (10)$$

where the distribution of the calculated statistic depends on the hypothesized number of cointegrating vectors r such that the statistic is distributed as a $\hat{A}^2(r)$ variate. Once the appropriate specification for the deterministic components is established, we may proceed to test the rank of β using the appropriate set of critical values.⁸

The next step is to use the Johansen procedure to analyze the individual parity conditions. Not only are tests of cointegration necessary, but when cointegration has been established, hypothesis tests on the cointegrating parameters are necessary in order to determine if the particular parity condition in fact holds. For example, when testing for UIP, not only is it necessary that nominal interest rates are cointegrated across countries but the cointegrating vector β must itself span the space $[1 \ -1]^0$. The estimate of β , $\hat{\beta}$, is given by the r -largest eigenvectors associated with the eigenvalues λ_i . Hypothesis tests on β can be conducted using likelihood ratio (LR) tests with standard \hat{A}^2 inference. Let the form of the linear restrictions on β be given by $\beta = H\gamma$ where H is a $p \times s$ matrix of restrictions and γ is a $s \times r$ matrix of unknown parameters. The LR test statistic is given by,

$$T \sum_{i=1}^r \ln \frac{(1 - \lambda_{i+1})}{(1 - \lambda_i)} \gg \hat{A}_{r(p-s)}^2 \quad (11)$$

where λ_i are the eigenvalues from the restricted MLE.

⁸We use critical values that have been tabulated by MacKinnon et al. (1996) using response surface regressions. These have been shown to approximate the true asymptotic distributions more closely than standard Monte Carlo derived critical values.

The next section will discuss the data and the results from the empirical analysis.

4 Empirical Results

4.1 Data

The data used in our study consist of monthly observations on twelve-month eurocurrency deposit rates and annualized inflation rates for the United States (US), United Kingdom (UK), Canada (CN), Germany (GM), and Japan (JP) over the period February 1960 to April 1996.⁹ This sample represents five of the largest and most open industrialized economies in the world, which we expect would be as likely as any to yield results favorable to the RIP hypothesis.

4.2 Testing the Necessary Condition for RIP

The first step in our analysis is to test the rank of β from (7). In order to make valid inference from the empirical estimates we must establish the specification for β_t . Table 1 presents the LR test statistics from implementing the tests in (9) where the null hypothesis is that there are no linear trends in the levels of the data.¹⁰ It is clear from these results that there is virtually no evidence contrary to this null hypothesis. Table 2 presents the calculated LR tests of the hypothesis that there are no significant deterministic components in the VAR. The evidence is somewhat mixed but it generally suggests that it is inappropriate to eliminate the constant from the estimated cointegrating relations. Therefore, we will conduct our tests of the rank of β based on a specification that does not include a constant in the VAR but does allow a constant term in the cointegration vector.

We use the Johansen trace test statistics to determine the rank of β as outlined in the previous section. We calculate a recursive or rolling estimate of the trace statistic in order to determine the sensitivity of our conclusions to

⁹The inflation rates are calculated as twelve times the log difference of the respective CPIs. All data are taken from the IFS database of the IMF.

¹⁰The lag length in the VAR was chosen such that it was the minimum necessary to eliminate all statistically significant residual serial correlation. This resulted in a lag length of 12 in all cases except for Germany-Canada which required 13 lags.

the particular sample period. We present the results graphically in Figures 3, 4 and 5 where the test statistics have been normalized by the appropriate 90% critical value such that values greater than one imply statistical significance at the 10% marginal level.

It's important to understand how critical the correct specification of the deterministic components in the VAR is for the inference on the rank of β : Figure 3 presents the rolling trace statistics estimated with a constant in the VAR, i.e. $H_1(r)$. In this case there is evidence of four cointegrating vectors in several of the bilateral relationships implying full rank of β : One might conclude based upon this evidence that the necessary conditions for RIP are approximately true among these countries.¹¹ But an examination of the rolling trace tests in Figure 4, estimated under $H_1^a(r)$, suggest entirely different conclusions about the time series properties of the data. In no case is there evidence of more than two cointegrating relationships, implying that at least two of the necessary conditions for RIP are being violated. Figure 5 presents rolling trace tests estimated with no constant terms in the VAR, $H_2(r)$: These graphs tell essentially the same story as those in Figure 4. Namely, that RIP cannot hold among these countries. The difference between the results in Figure 3, estimated under $H_1(r)$, and Figure 4, estimated under $H_1^a(r)$; is in the choice of appropriate critical values, not the actual test statistic values, which are very close to each other as demonstrated in table 1.

4.3 Testing Individual Parity Conditions

Table 3 presents the results from our analysis of the Fisher relation in each country. While the evidence in favor of cointegration is mixed, the overall results support the Fisher relationship.¹² In no case can we reject the Fisher restriction that nominal interest rates and inflation rates move one-for-one over the long haul.

Table 4 presents the results from testing the ten UIP relationships possible. While there appears to be some strong evidence of cointegration in many of the relationships, there are only three bilateral relationships consistent with the UIP restrictions. These are the U.S and the U.K., Canada

¹¹This does not imply the RIP is a valid characterization of the data, only that the necessary condition that all germane variables are stationary is supported.

¹²It turns out that the data for the Fisher relationships generally favor the $H_2(r)$ specification. When this specification is used the cointegration results are stronger and parameter restrictions are more consistent with the theoretical model.

and the U.K., and the U.S. and Canada. In the other seven bilateral relations, either the evidence in favor of cointegration is very weak or the UIP parameter restrictions are strongly rejected.

Table 5 presents the evidence for bilateral EAPPP relationships. The evidence here is quite mixed. Half of the bilateral relations exhibit evidence of cointegration, but of these two reject the parameter restrictions implied by EAPPP. The EAPPP relation seems to be strongest for the Japan and the U.K. system and the U.S. and Canada system. Germany seems the least likely to share an EAPPP equilibrium relationship with any of the other countries.

5 Conclusions

In this study we set out to achieve a couple of objectives. First we wanted to demonstrate that real interest rate parity and the underlying parity conditions, uncovered interest parity, ex-ante PPP and the Fisher relation in each country, imply that the underlying variables must all be stationary if RIP is to be a valid long-run characterization of the data. Using a procedure advocated by Taylor and Sarno (1998) we reject the hypothesis that all of the germane variables are stationary.

Our second objective was to identify which of the four underlying parity conditions may be responsible for the RIP rejections. We estimated and tested for twenty-five bilateral equilibrium relationships. From these we were able to conclude that the Fisher relation has wide support empirically but that UIP and EAPPP have much more limited support.

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Table 1: Test for Linear Trends in Data

Country Pair	$r = 0$	$r = 1$	$r = 2$	$r = 3$
JP-UK	0.747	0.500	0.500	0.306
CN-UK	0.034	0.034	0.034	0.028
CN-JP	0.549	0.452	0.311	0.290
CN-US	0.190	0.188	0.153	0.034
JP-US	0.790	0.669	0.551	0.496
UK-US	0.128	0.116	0.105	0.102
GM-US	0.315	0.290	0.172	0.169
GM-CN	0.095	0.048	0.015	0.006
GM-JP	0.466	0.456	0.020	0.000
GM-UK	0.194	0.109	0.066	0.062
95 % critical value	9.49	7.81	5.99	3.84

Note: Entries represent the calculated LR test statistics from (9). r represents the hypothesized number of cointegrating vectors under the null hypothesis.

Table 2: Test for No Deterministic Components in Vector Autoregression

Country Pair	$r = 1$	$r = 2$	$r = 3$	$r = 4$
JP-UK	0.880	4.904	8.112	11.746
CN-UK	4.308	5.159	9.599	12.575
CN-JP	5.432	13.379	16.293	20.186
CN-US	0.038	4.488	6.218	10.847
JP-US	1.600	4.612	11.315	14.596
UK-US	5.770	6.028	8.712	12.926
GM-US	0.514	8.568	11.017	16.113
GM-CN	0.180	12.235	12.424	17.476
GM-JP	0.057	3.437	7.205	11.247
GM-UK	0.884	2.731	5.635	10.887
95 % critical value	3.84	5.99	7.81	9.49

Note: Entries represent the calculated LR test statistics from (10). r represents the hypothesized number of cointegrating vectors under the null hypothesis.

Table 3: Test for Fisher Relation

Country	$r = 0$	$r = 1$	$H_0 : \beta = [1 \quad 1]'$
US ^a	17.11	7.37	0.01
UK	12.84	4.70	3.20
CN ^a	16.77	5.08	0.71
GM ^a	33.82	7.61	1.08
JP ^a	24.69	7.09	3.66
95 % critical value	17.98	7.56	3.84

Note: Entries represent the calculated trace test statistics where r represents the hypothesized number of cointegrating vectors and null hypothesis of H_0 is distributed as a $\hat{\Lambda}_1^2$ variate. ^a _{i} Denotes that Fisher relation holds in this country.

Table 4: Test of UIP Relation

Country Pair	$r = 0$	$r = 1$	$H_0 : \beta = [1 \quad 1]'$
JP-UK	12.21	4.32	3.56
CN-UK ^a	22.81	6.24	0.03
CN-JP	13.58	5.85	1.82
CN-US ^a	17.97	7.05	0.23
JP-US	14.38	4.84	4.41
UK-US ^a	18.76	6.63	0.18
GM-US	30.27	4.23	18.91
GM-CN	30.78	5.65	16.44
GM-JP	34.30	7.41	16.56
GM-UK	30.55	6.19	13.71
95 % critical value	17.98	7.56	3.84

Note: Entries represent the calculated trace test statistics where r represents the hypothesized number of cointegrating vectors and null hypothesis of H_0 is distributed as a $\hat{\Lambda}_1^2$ variate. ^a _{i} Denotes that UIP relation holds for this country pair.

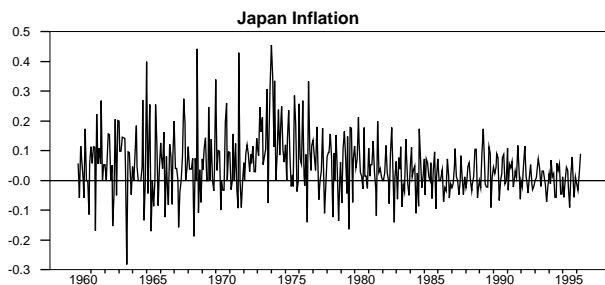
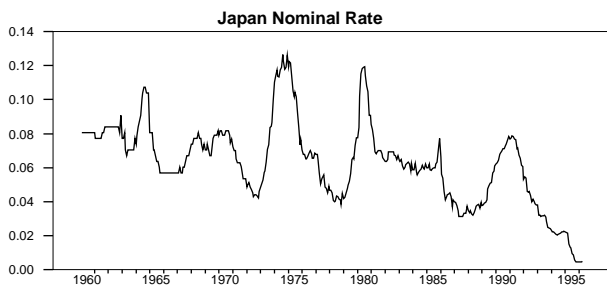
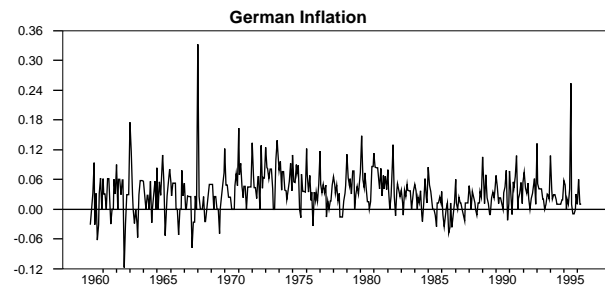
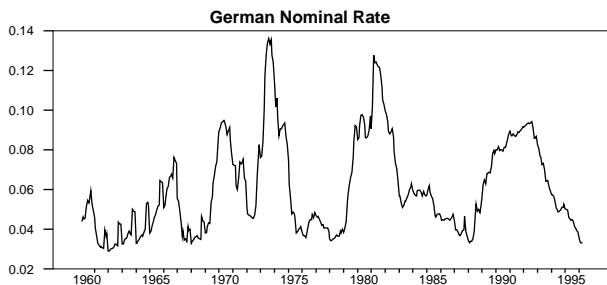
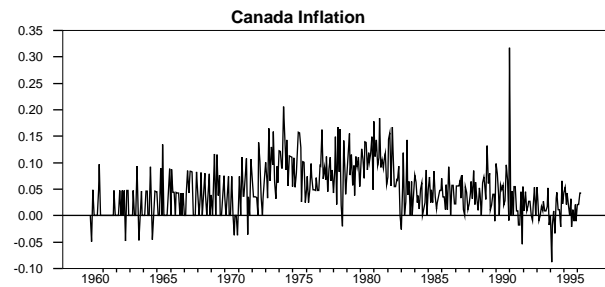
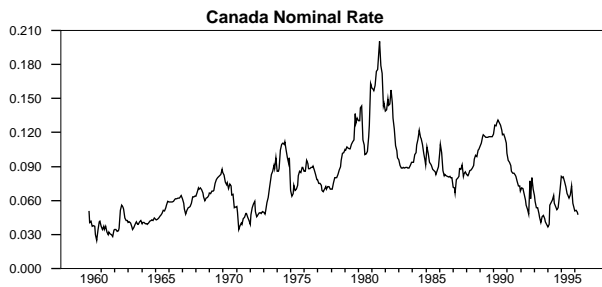
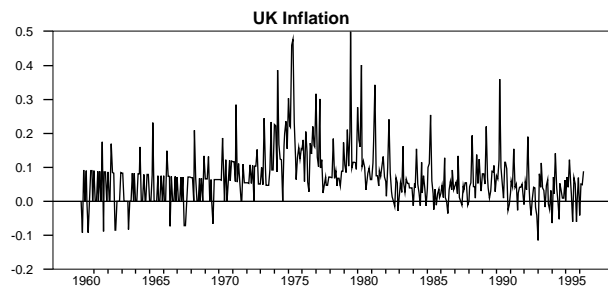
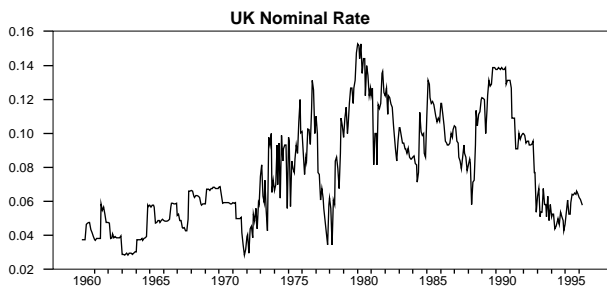
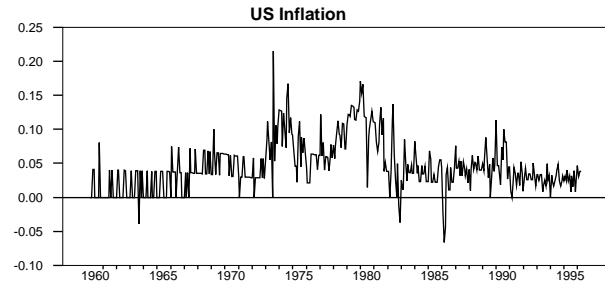
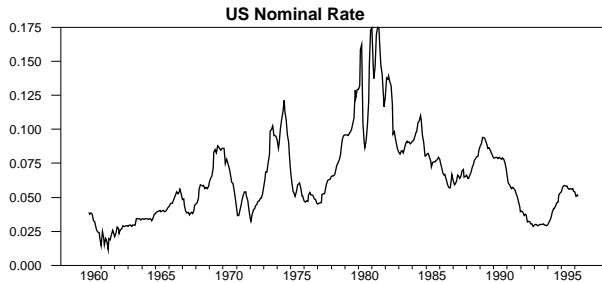
Table 5: Test of EAPPP Relation

Country Pair	$r = 0$	$r = 1$	$H_0 : \beta = [1 \ 1 \ 1]'$
JP-UK ^a	19.62	3.61	1.03
CN-UK ^a	17.87	2.45	3.36
CN-JP	12.32	3.79	0.01
CN-US ^a	24.30	4.38	0.87
JP-US	12.22	5.68	0.12
UK-US ^a	20.33	6.41	3.11
GM-US	16.12	5.67	2.92
GM-CN	14.39	3.65	4.01
GM-JP	17.78	4.55	5.32
GM-UK	14.69	4.45	4.68
95 % critical value	17.98	7.56	3.84

Note: Entries represent the calculated trace test statistics where r represents the hypothesized number of cointegrating vectors and null hypothesis of H_0 is distributed as a $\hat{\Lambda}_1^2$ variate. ^a _{i} Denotes that EAPPP relation holds for this country pair.

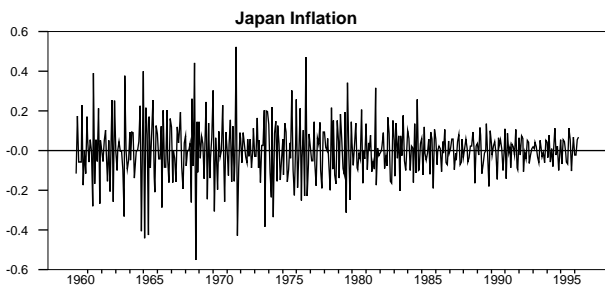
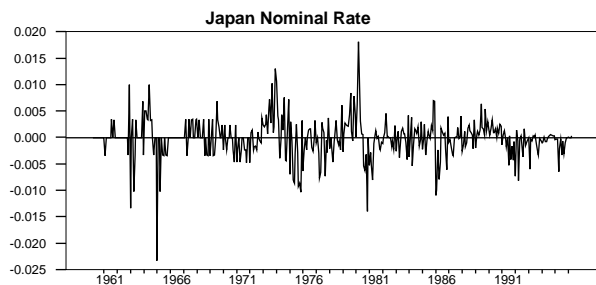
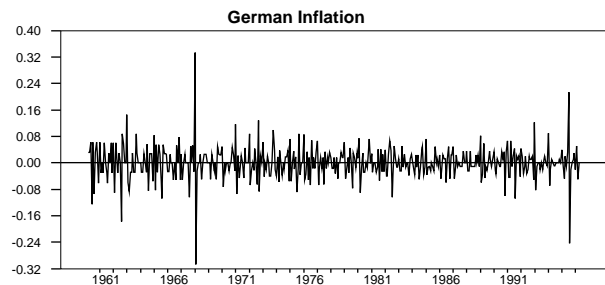
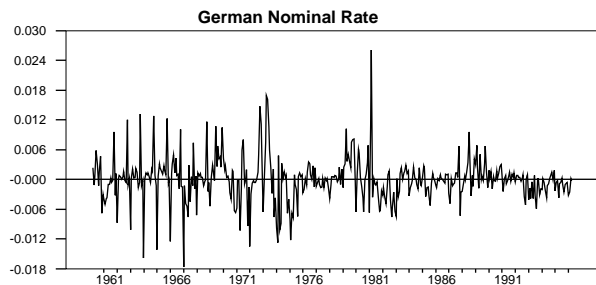
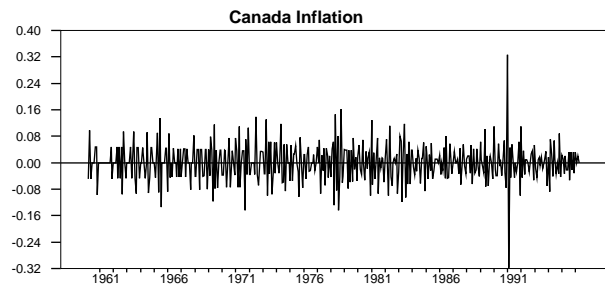
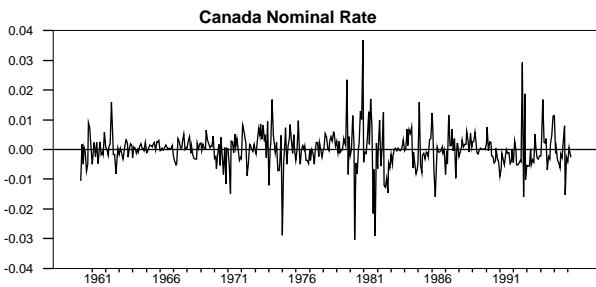
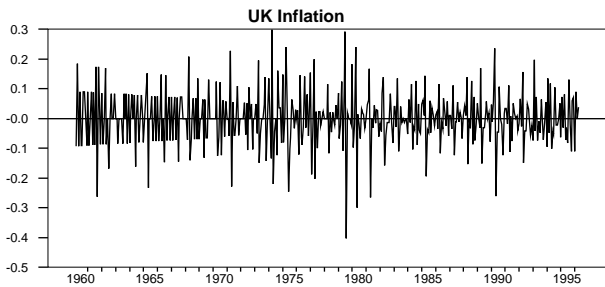
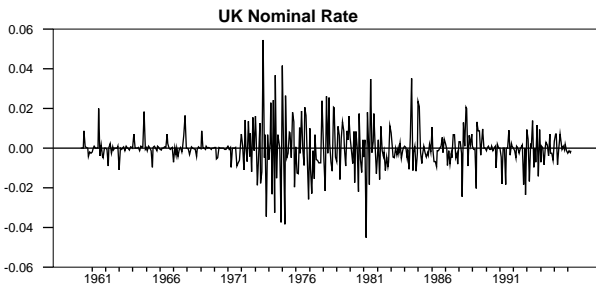
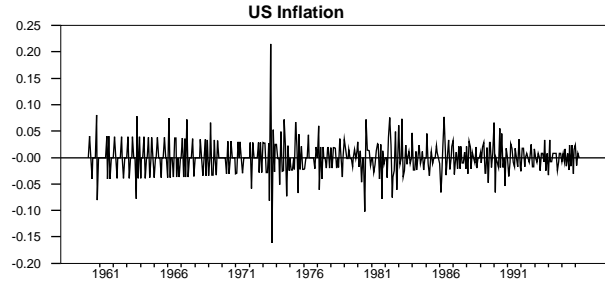
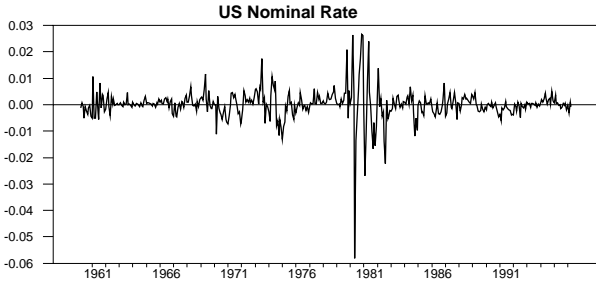
Nominal Interest Rates and Inflation Rates

Levels



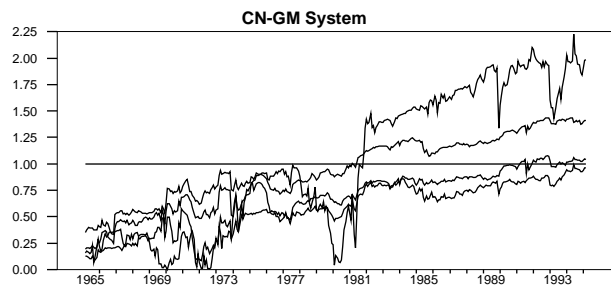
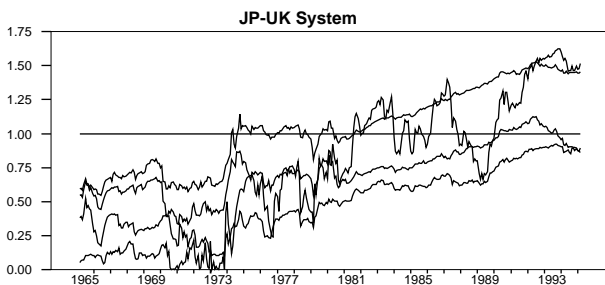
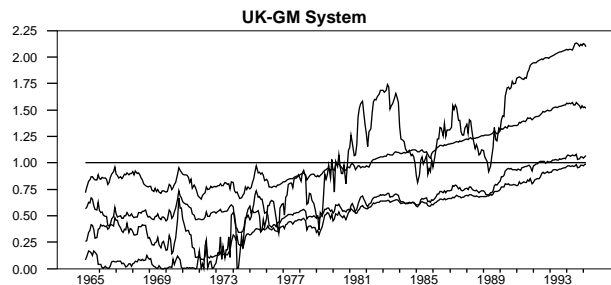
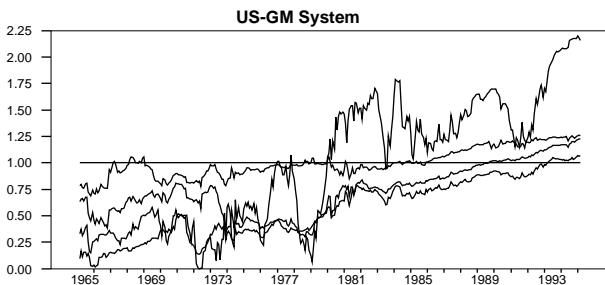
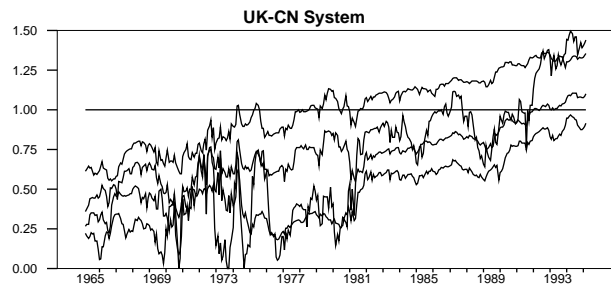
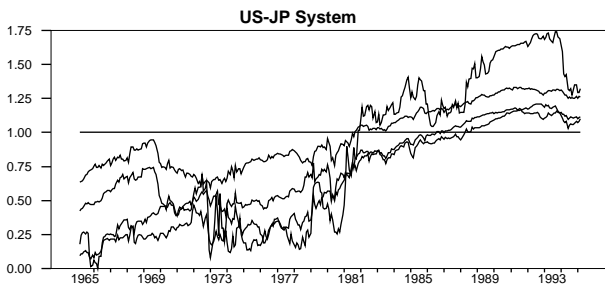
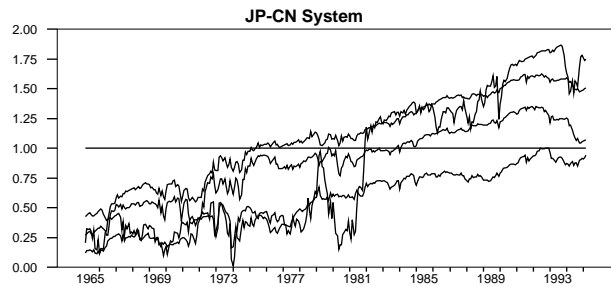
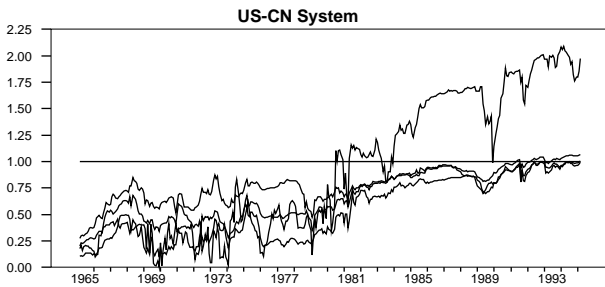
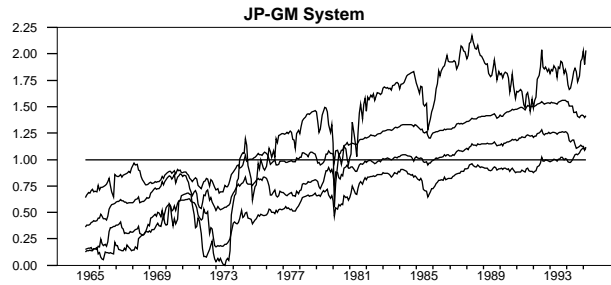
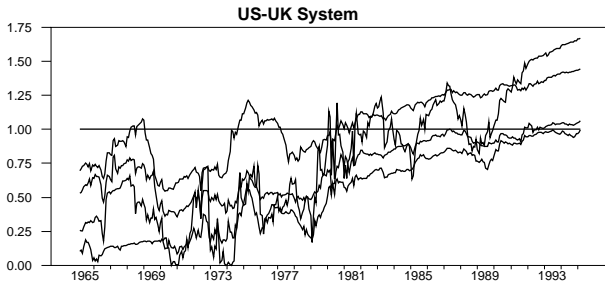
Nominal Interest Rates and Inflation Rates

First Differences



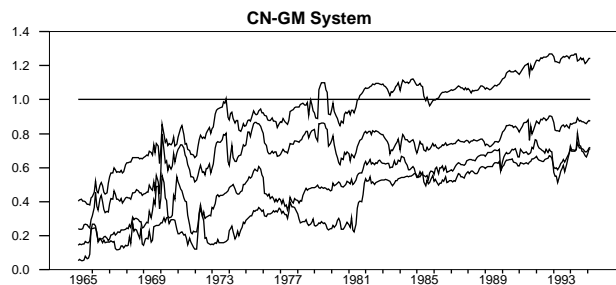
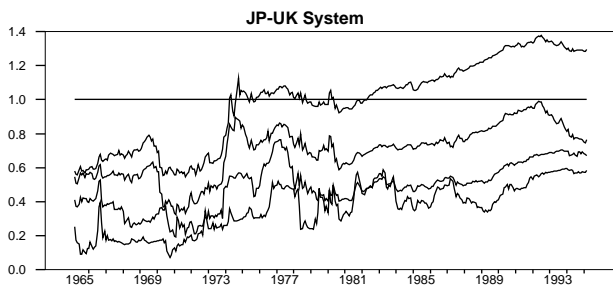
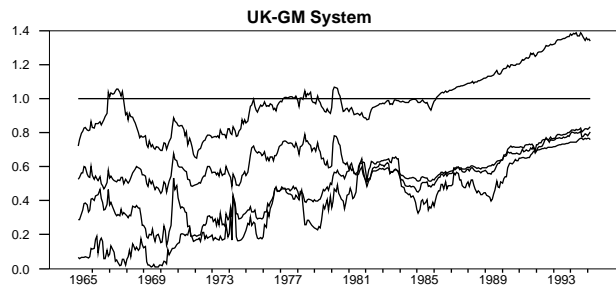
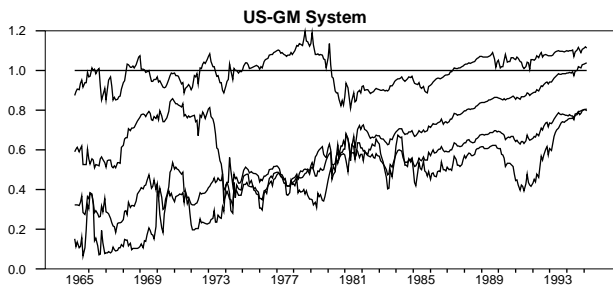
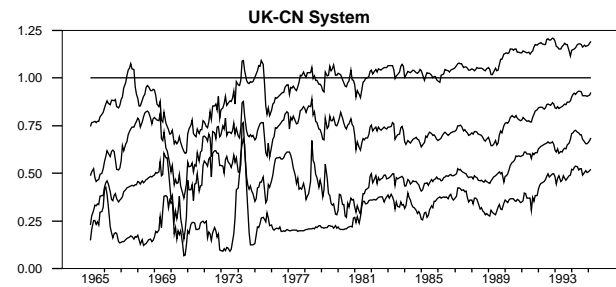
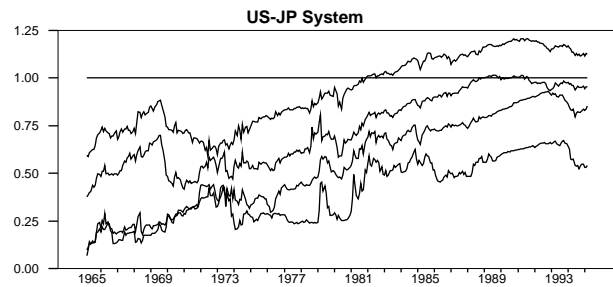
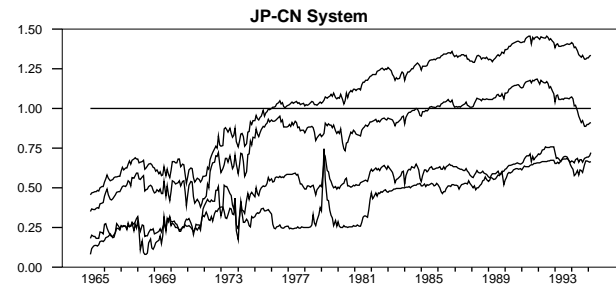
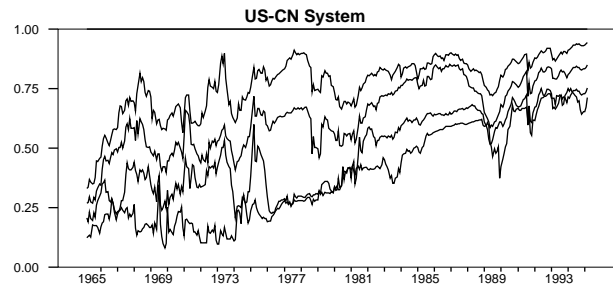
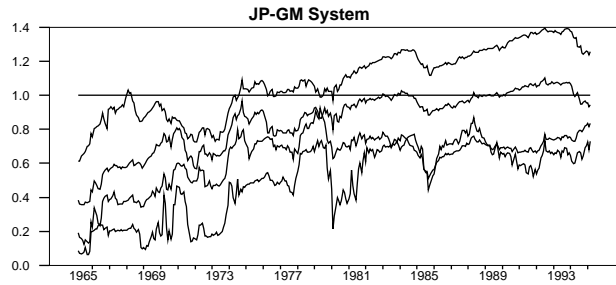
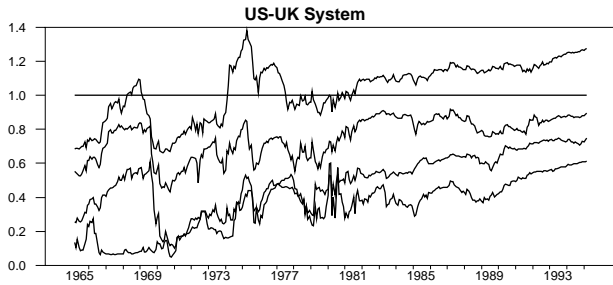
Rolling Trace Test Statistics

Linear Trend in Levels Data



Rolling Trace Test Statistics

Constant Term in Cointegrating Vector



Rolling Trace Test Statistics

No Deterministic Terms

