HYSTERESIS IN UNEMPLOYMENT? EVIDENCE FROM PANEL UNIT ROOT TESTS WITH STRUCTURAL CHANGE

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I. INTRODUCTION

The idea that the rate of unemployment should fluctuate around a long-run steady-state or “natural rate” is one of the central theories of macroeconomics (see, e.g., Phelps 1967, 1968, and Friedman, 1968). Within this framework, deviations in unemployment from the natural rate should be temporary. The theory describes well the observed movements in unemployment during the 1950s and 1960s. However, the behavior of unemployment rates in many countries, particularly in Europe, in the 1970s and 1980s seems to question the validity of the natural rate paradigm. As a result, Blanchard and Summers (1987) theorize that unemployment might be characterized by “hysteresis”; that is, movements in unemployment might incorporate a long-term persistence. A third theory describing unemployment is suggested by Phelps (1994). According to this view, most shocks to unemployment are temporary, but occasionally the natural rate will permanently change. As a consequence, the unemployment rate may be characterized as a process that is stationary around a small number of (permanent) “structural breaks.”

Following development of the hysteresis theory, researchers began to empirically test its validity. Because hysteresis is consistent with non-stationary unemployment rates, unit root tests provide a convenient methodological framework in which to empirically investigate this hypothesis. Accordingly, empirical studies on this issue adopt unit root tests to investigate this hypothesis. The finding of a unit root in unemployment would imply that this series does not fluctuate around a predictable level. Under this scenario, all shocks permanently alter the unemployment rate with no tendency to return to some stable "natural rate." Obvious implications arise regarding policy actions to counteract shocks to unemployment depending on whether they are permanent or temporary. The validity of hysteresis is, therefore, important for both theory and policy implications.

We examine the validity of the hysteresis hypothesis with annual unemployment rate data from seventeen OECD countries for the time period 1955-1999. To perform our tests, we employ a panel LM unit root test that allows for heterogeneous structural change. Our study is similar in nature to that of Song and Wu (1997, 1998) in terms of pooling the data, but their papers do not allow for heterogeneity in the persistence parameter or possible structural changes. When testing for a unit root, numerous researchers now regularly allows for structural change in the testing regression. Despite the importance of controlling for structural change, to the best of our knowledge no previous studies of hysteresis allow for structural change in panel unit root tests. One obvious reason for this is the difficulty of allowing for structural change in the usual panel unit root tests. It is well known that the distribution of Dickey-Fuller type unit root tests allowing for structural change depend on nuisance parameters describing the breaks (see, e.g., Perron, 1989). Accordingly, the distribution of test statistics using the popular panel unit root test of Im, Pesaran, and Shin (1997, hereafter referred to as the IPS test) or Levin and Lin (1992), which extend the univariate Dickey-Fuller type unit root test, should also depend on nuisance parameters when allowing for structural change. Thus, finding relevant critical values is not an easy task, since one needs to simulate new critical values corresponding to numerous combinations of break points in the panel.

Dependence on nuisance parameters is an obvious hindrance to empirical researchers wishing to implement a Dickey-Fuller type panel unit root test with breaks(s).

Contrary to this, the panel LM unit root test employed in our work is free of the nuisance parameter problem. This is because the asymptotic distribution of the panel LM test with break is the same as that of the panel LM test without break. This desirable property makes it possible to allow for a finite number of breaks without the necessity of simulating new critical values corresponding to numerous combinations of break points. In particular, the critical values for the panel LM unit root test with break are the same as those for the panel LM unit root test without break and regardless of differing combinations of the finite number of break points occurring in each country. We take advantage of this invariance property and jointly estimate endogenously from the data the heterogeneous optimal number and location of breaks for each country. In addition, as in the IPS test, we consider heterogeneous panels by using different persistence parameters in each country. Our results indicate that the unemployment hysteresis hypothesis is strongly rejected for OECD countries.

The remainder of the paper proceeds as follows. Section 2 explores the history of testing for hysteresis in unemployment. Section 3 describes the testing methodology that we employ. Section 4 describes the data, performs the tests, and discusses the results. Section 5 concludes.

II. TESTING FOR HYSTERESIS

The work of Phelps (1967, 1968) and Friedman (1968) during the mid-1960s set the tone for further macroeconomic research on unemployment. Stylized facts observed since have led researchers to question previous notions of unemployment behavior.[1] In particular, higher unemployment rates experienced by many countries in recent decades led some researchers to hypothesize that unemployment rates might be characterized by hysteresis.[2] As noted above, because hysteresis is consistent with nonstationary unemployment rates, unit root tests have been widely used to empirically investigate this hypothesis.

Neudorfer, Pichelmann, and Wagner (1990) provide one of the earliest empirical studies that use conventional unit root tests to investigate hysteresis effects on unemployment. Using standard Dickey-Fuller (1979) unit root tests, they are unable to reject the unit root null and, therefore, the hysteresis hypothesis for Austria. Mitchell (1993) uses Perron's (1989) unit root test, which assumes one exogenously given structural break, and finds similar support for the unit root hypothesis and hysteresis in several OECD countries. Jaeger and Parkinson (1994) apply standard augmented Dickey-Fuller unit root tests to unemployment rates in Canada, Germany, the U.K., and the U.S. They are unable to reject the null hypothesis of a unit root and hysteresis in any case. Their subsequent use of an unobserved components model also provides evidence in favor of hysteresis effects in each country except the U.S. Røed (1996) offers a more detailed analysis of unemployment data by employing the augmented Dickey-Fuller unit root test, as well as the Kwiatkowsky, Phillips, Schmidt, and Shin (1992) test for

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[1] Layard, Nickell, and Jackman (1991) provide a detailed analysis of unemployment rates in European countries, among others, from the post-war period to the present.

[2] Røed (1997) provides a summary of various factors that have been proposed to explain hysteresis in unemployment rates.

stationarity. Røed finds significant hysteresis effects in the rate of unemployment for Australia, Canada, Japan, and several European countries over the period 1970-1994.

Despite the fact that the above research tends to support a unit root in unemployment and, therefore, hysteresis, many economists find this evidence to be unappealing and counterintuitive. Critics of the hysteresis theory claim that empirical support may be due to the low power of conventional unit root tests. For example, Leslie, Pu, and Wharton (1995) simulate data designed to mimic unemployment rates in the major OECD countries and find a poor power performance using conventional unit root tests. They show that the standard Dickey-Fuller and Phillips-Perron unit root tests frequently indicate a series is difference stationary when, in fact, the series is stationary in levels.

Since publication of early empirical research on unemployment hysteresis, several econometric advances have been made that can potentially increase the power of unit root tests. As a result, the empirical validity of the hysteresis hypothesis has been recently re-examined. Two distinct directions of testing have developed: (1) panel unit root tests, and (2) univariate unit root tests with structural break(s). Song and Wu (1997, 1998) pool data from forty-eight U.S. states and fifteen OECD countries, respectively, and employ the panel unit root test of Levin and Lin (1992). They reject the unit root null and hysteresis in each case. Arestis and Mariscal (2000) apply the structural break univariate unit root test of Perron (1997) to unemployment rates from twenty-two OECD countries. The test allows for one endogenously determined structural break in each unit root test. Although their results are mixed, they mostly reject the unit root null and hysteresis. Papell, Murray, and Ghiblawi (2000) apply the univariate unit root test of Perron and

Vogelsang (1992), which allows for one endogenously determined structural break, to test for hysteresis in each of sixteen OECD countries. Without allowing for structural change, their conventional unit root tests are generally unable to reject the null and hysteresis in all cases. After allowing for structural change, they reject the unit root null and hysteresis in ten of sixteen countries. Overall, the above empirical findings are mixed, but in general, compared to the early empirical research, the recent studies find little if any support for unemployment hysteresis. This difference in findings is most likely due to the increased power to reject the unit root null by utilizing panel data tests or allowing for structural breaks.

Despite the fact that the testing methodologies employed in the more recent research offer distinct advantages over those earlier employed, none of these tests combine panel data and structural breaks. In an effort to seek a more accurate and complete investigation of hysteresis, our paper extends the previous research by employing the panel LM unit root test developed by Im and Lee (2001). This test has the advantage of utilizing *both* panel data and structural breaks when testing for a unit root. As previously noted, controlling for structural change in the existing Dickey-Fuller type panel unit root test is difficult due to nuisance parameter problems. Unlike the IPS and other related panel unit root tests, the panel LM test can successfully take structural breaks into account without the necessity of simulating new critical values that depend on the number and location of break points. Combining these two productive avenues of testing can potentially lead to even greater power when testing for hysteresis in unit root tests.

III. PANEL LM UNIT ROOT TESTS

To illustrate the underlying model and testing procedure, the following data generating process (DGP) is considered:

(1) $Y_{it} = \delta' Z_{it} + \gamma_t + X_{it}$, $X_{it} = \beta_i X_{i,t-1} + \varepsilon_{it}$,

where y_{it} is the i-th cross-section unit in the panel measured in period t, and Z_{it} is a vector of exogenous variables. $A(L)\varepsilon_{it} = B(L)u_{it}$, where $A(L)$ and $B(L)$ are finite order polynomials and $u_{it} \sim$ iid $(0,\sigma_i^2)$. We assume no cross-correlation in the error terms, implying that $E(u_{it}u_{js}) = 0$, $\forall\, i \neq j$ and $t \neq s$. The unit root null hypothesis implies that $\beta_i = 1$, as in the IPS test. We consider heterogeneous panel data models where the persistence coefficient β_i is allowed to vary over each country. The panel LM test is derived from the above DGP, which makes the asymptotic distribution of the test statistic invariant to the break parameter included in δ'.

As described in Perron (1989), we consider the "crash" Model A, which allows for a one-time change in level. More general structural break models, such as the "changing growth" model or a model allowing for change in both the level and trend, are not considered here, since the invariance property of the panel LM test statistic does not hold. However, focusing on the crash model may be sufficient, since it is commonly assumed that the natural rate of unemployment is not subject to a change in trend. We define $Z_{it} = [1, t, D_{it}]'$ to allow for a change in level, where $D_{it} = 1$ for $t \geq T_{Bi} + 1$, and zero otherwise.

The model considers *heterogeneous* structural changes by allowing for different location of the break points (T_{Bi}) in each country. In addition, the break points are endogenously determined from the data. It is important to note that the LM panel unit root test allows for a possible break under the null, as well as under the alternative hypothesis. For instance, depending on the value of β_i, the null hypothesis is given by:

(2) $y_{it} = \mu_{0i} + d_i B_{it} + y_{i,t-1} + v_{it}$.

This setting of the null model is contrary to the Dickey-Fuller type endogenous break tests, which typically do not allow for the possibility of a break (B_{it}) under the unit root null hypothesis. As demonstrated in Nunes, Newbold, and Kuan (1997), the presence of a structural break under the null can lead to significant size distortions and spurious rejections in Dickey-Fuller type endogenous break unit root tests. In contrast, the LM unit root test with endogenous breaks is not subject to spurious rejections (Lee and Strazicich, 1999b).

The panel LM unit root test statistic is derived from results of the univariate LM unit root test. Test statistics for each country are obtained from the following regression according to the LM (score) principle:

(3) $\Delta y_{it} = \delta_i{}'\Delta Z_{it} + \phi_i \tilde{S}_{i,t-1} + u_t$,

where $\tilde{S}_{it} = y_{it} - \tilde{\psi}_{xi} - Z_{it}\tilde{\delta}_i$, $i=1,..N; t=2,..,T$, $\tilde{\delta}_i$ is a vector of coefficients in the regression of Δy_{it} on ΔZ_{it}, and $\tilde{\psi}_{xi}$ is the restricted maximum likelihood estimate of ψ_{X_i} $(\equiv \psi_i + X_{0i})$ given by $y_{i1} - Z_{i1}\tilde{\delta}_i$ (see Schmidt and Phillips, 1992).

Correction for autocorrelated errors is accomplished by including augmented terms $\Delta\tilde{S}_{i,t-j}$, $j=1,..,k$, in (3), as in the standard ADF test. To empirically implement correction for potential higher-order serial correlations, the number of k augmented terms $\Delta\tilde{S}_{i,t-j}$, $j = 1,..,k$, included in each testing equation is endogenously determined. At the same time, we determine the breaks of each country. To determine jointly both the break points and the number of lagged first-differenced terms, we determine the value of *k* at each combination of break point(s). Then, using this "optimal" value of *k*, we determine the break point.[3] To determine the optimal *k*, a general to specific procedure is employed for each time series. Beginning with a maximum number of lagged terms *maxk* = 8, the last augmented term $\Delta\tilde{S}_{i,t-8}$ is examined to see if it is significantly different from zero at the 10% level (asymptotic normal critical value is 1.645). If insignificant, the term is dropped from the testing regression and the model is re-estimated using $k = 7$ terms, etc., until the maximum lagged term is found or $k = 0$, at which point the procedure stops.

The unit root null hypothesis can be described by $\phi_i = 0$ and the LM test statistic for each time series is given by:

(4) $\tilde{\tau}_i$ = *t*-statistic testing the null hypothesis $\phi_i = 0$.

To determine the break point T_{Bi} endogenously in each time series, we utilize the procedure employed in the "minimum LM test." In other words, we use a grid search to determine the break at the location where the *t*-test statistic is minimized:

$$(5) \qquad LM_{\tau i} = \underset{\lambda_i}{Inf}\, \tilde{\tau}(\lambda_i) \ .$$

The procedure is repeated at each combination of break points $\lambda = T_B/T$ over the time interval [.1*T*, .9*T*], where *T* is the sample size. We use the optimal lags (*k*) determined for each break point as described above. Critical values in the LM unit root test for Model A

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[3] Alternatively, one may first determine the break point (T_B) assuming no serial correlation (k=0) and then estimate the optimal lag terms (k). This method, while simpler to implement, will not guarantee estimation of the optimal values of both k and T_B.

are invariant to the break location (λ), so the same critical values can be used throughout, regardless of the break location in each country. Fortunately, this desirable property carries over to the panel LM test with breaks.

The distribution of the $LM_{\tau i}$ test statistic depends on N and T, but does not depend on any other parameters under the null hypothesis. Following Im and Lee (2001), we denote the average of the individual (single country) LM test statistics ($LM_{\tau i}$) as:

$$(6) \qquad \overline{LM}_{NT} = \frac{1}{N} \sum_{i=1}^{N} LM_{\tau i} \quad .$$

We denote the expected value and variance of $LM_{\tau i}$ under the null hypothesis as $E(L_T)$ and $V(L_T)$, respectively. (Values for $E(L_T)$ and $V(L_T)$ come from Table 1 of Im and Lee, 2001.) The standardized LM panel unit root test statistic is then obtained as follows:

$$(7) \qquad \Gamma_{LM} = \frac{\sqrt{N}\,[\,\overline{LM}_{NT} - E(L_T)]}{\sqrt{V(L_T)}} \quad .$$

Im and Lee (2001) derive the asymptotic properties of (7) and show it has a standard normal distribution.

To correct for autocorrelated errors, we use a weighted average of $E(L_T(k_i))$ and $V(L_T(k_i))$ chosen to be consistent with the heterogeneous optimal values of k_i selected for each country. Im and Lee (2001) show that the expected value and variance of $LM_{\tau i}$ remains the same in the panel LM test with or without a break in each time series. Therefore, the standardized panel LM test statistic in (7) remains the same with or without a structural break. This attractive result is due to the fact that the distribution of the panel LM unit root test statistic is unaffected by break(s) under the null and holds even if break locations differ in each country. This invariance result holds for any heterogeneous finite number of breaks. Therefore, we do not have to simulate new critical values depending on the location and number of heterogeneous breaks. The hypotheses tested in panel data can be described as follows:

Null Hypothesis: $\beta_i = 0$ *for all i,*

Alternative Hypothesis: $\beta_i < 0$ *for at least one i .*

IV. DATA AND RESULTS

The mixed results from unit root tests in previous research on unemployment hysteresis suggests that the question remains as to whether or not the theory is empirically valid. To perform our tests, we employ annual data on unemployment rates from seventeen OECD countries over the period 1955-1999. Our data comes from various issues of "Labor Force Statistics" as published by the OECD.[4] This data is advantageous as it covers a fairly long time span of forty-five years and comes from the same (OECD) source.

In order to provide a robust analysis, we compare both univariate and panel LM unit root test results with and without structural breaks. We begin with the Schmidt and Phillips univariate LM unit root test without structural change. We then move to extensions that allow for multiple breaks, since our time series covers periods during which structural change may have occurred, especially during the 1970s and 1980s. In addition to the Schmidt and Phillips no-break test, we employ the univariate one- and

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[4] The seventeen countries are Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Ireland, Italy, Japan, the Netherlands, Norway, Spain, Sweden, the U.K., and the U.S. The time period covered is 1955-1999, except for 1956-99 in Spain and the U.S., 1955-98 in Italy and Norway, and 1956-98 in the U.K.

two-break minimum LM unit root tests of Lee and Strazicich (1999a, 1999b) to determine the number of structural breaks in each country. After determining the optimal number of breaks, we employ the panel LM unit root test of Im and Lee (2001). For comparison, we additionally show the panel LM test results with no breaks.

To determine the optimal break point(s) in the panel LM test, we utilize the univariate "minimum" LM unit root tests of Lee and Strazicich (1999a, 1999b). These tests are comparable to the corresponding Dickey-Fuller type endogenous break tests of Zivot and Andrews (1992) and Lumsdaine and Papell (1997). The performance of the LM test is comparable to or superior to these counter-part tests in terms of size and power. In addition, the LM unit root tests are not subject to spurious rejections under the null. In each test, the break points are determined endogenously from the data via a grid-search by selecting the break(s) where the unit root test statistic is a minimum (i.e., the most negative). Using the minimum LM tests of Lee and Strazicich (1999a, 1999b), the unit root test statistic is estimated at each combination of one ($\lambda = T_B/T$) and two-break points ($\lambda = (\lambda_1, \lambda_2)'$, $\lambda_j = T_{Bj}/T$, j=1,2), respectively. (T_B and T_{Bj} is the time period of one and each of two breaks, respectively, and T is the sample size.) The procedure is repeated over the time interval [$.1T$, $.9T$], to eliminate end points, until the breaks are determined where the unit root *t*-test statistic is minimized.

The optimal number of breaks in each country is determined by sequentially examining the *t*-statistic for each break coefficient to see if it is significant at the approximate 10% level in an asymptotic normal distribution. We begin with the two-break LM test. If less than two break points are significant, then the one-break LM test is employed. If less than one break is significant, we employ the no-break LM unit root test of Schmidt and Phillips (1992). The corresponding LM unit root test statistic is then chosen after determining the optimal number of breaks.[5] After determining the appropriate unit root test statistic for each country, the (standardized) panel LM test statistic is then calculated as in (7).[6]

The results of testing are shown in Table 1. For the univariate LM test with no break, the unit root null cannot be rejected in any case at the usual significance levels. After allowing for structural breaks, the univariate minimum LM test rejects the unit root null in only two of seventeen countries (Australia and Finland) at 10% and 5%, respectively. Despite the inclusion of structural breaks, the univariate unit root tests are unable to reject the null in nearly all cases. Examination of the estimated break points reveals, as suspected, that most structural breaks in unemployment occur during the early 1970s and 1980s. In particular, eighty percent of all breaks occur during the years 1973-1974 and 1980-1982; both of which are associated with significant recessions. In seven countries, no structural break is identified in any time period.

We next examine the panel test results. Without allowing for structural breaks, the panel LM test statistic of -0.033 clearly indicates a failure to reject the unit root null,

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[5] One may want to suggest allowing for more than two breaks, since we have not considered more than two breaks in each country. Although the invariance result of the LM unit root test should hold for any finite number of breaks, the finite sample properties of the test using more than two breaks would be an empirical issue. It is certainly plausible to consider more than two breaks, but we cannot proceed in this direction due to the huge computational burden in simulating critical values and finding the endogenous break points. Further, the finite sample performance of the test has not yet been examined.

[6] Note that country-specific fixed effects are allowed in the panel tests, since the test statistic is calculated from the univariate tests, which include heterogeneous intercept terms. It is not necessary to adjust (i.e., demean) for common year-specific fixed effects in the panel, since we specifically want to identify structural breaks, common and otherwise, in our unit root test.

in spite of increased power from panel data. This highlights the importance of allowing for structural change, even in the panel setting. After allowing for structural breaks, the panel test statistic of –2.627 strongly rejects the unit root null at less than 1% (p-value is approximately 0.4%). These results clearly demonstrate the gain in power from combining structural breaks with panel data.

Since the panel LM test statistic is calculated using the average test statistic of all countries, it is possible that the panel results are due to a small number of "outliers" having a relatively large impact. Examination of the univariate test statistics (with breaks) for each country reveals that Finland might qualify as such an outlier, as it is the only country that rejects the unit root null at 5%. To see if our panel results are robust to a possible outlier effect, we recalculate the panel LM test statistic (with breaks) omitting Finland. The resulting panel test statistic of –1.572 continues to reject the unit root null at conventional significance levels (p-value is approximately 5.8%). We can, therefore, be confident that the panel test results are not due to outliers. Overall, these results demonstrate that a failure to reject the null in the univariate tests is due to insufficient power. After combining structural breaks with panel data, the hysteresis null hypothesis is clearly rejected. Overall, our findings support a theory similar to Phelps (1994), and suggest that the overwhelming majority of shocks to unemployment are temporary, but on infrequent occasions, associated with significant recessions, "shocks" can permanently alter the natural rate of unemployment.[7]

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[7] While Song and Wu (1998) and Papell, Murray, and Ghiblawi (2000) also reject unemployment hysteresis in OECD countries, there are important differences in test results. Song and Wu ignore structural breaks and employ the Levin and Lin (1992) panel unit root test, which imposes the restrictions on the parameters. In addition, the absence of break points in their tests leads them to characterize unemployment by the (strict) natural rate hypothesis rather than the less

V. CONCLUDING REMARKS

This paper re-examines the empirical validity of hysteresis in unemployment rates using post-war annual data from seventeen OECD countries for the period 1955-1999. We employ a variety of unit root tests, including the recently developed panel LM unit root test of Im and Lee (2001) that allows for heterogeneous structural change. By combining the use of structural breaks and panel data, our tests realize a significant gain in power as compared to previous empirical research. Contrary to univariate tests and/or those tests that ignore structural breaks, by combining panel data with structural breaks the unemployment hysteresis hypothesis is strongly rejected.

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restrictive theory of occasional permanent shocks suggested in Phelps (1994). Whereas Papell *et al*. allow for a structural break in their unit root tests, our tests have potentially greater power given that we allow more breaks and utilize panel data. This difference in testing methodology likely explains the stronger rejections of the null in our tests.

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TABLE 1

LM Unit Root Test Results

	LM Unit Root Test Without Break		**LM Unit Root Test With Optimal Number of Breaks**		
Country	Test Statistic	Optimal *k*	Test Statistic	Break point(s) (T_{B1}, T_{B2})	Optimal *k*
Australia	−1.69	8	−3.77*	1974, 982	5
Austria	−1.35	0	−1.81	1986	1
Belgium	−2.22	1	−2.48	1974, 1980	1
Canada	−1.32	6	−1.32	-	6
Denmark	−1.70	1	−1.61	1973, 1980	0
Finland	−2.51	2	−4.77**	1990	1
France	−1.49	1	−1.76	1974, 1980	1
Germany	−1.87	1	−1.70	1974, 1981	1
Ireland	−2.45	8	−2.84	1988	8
Italy	−1.11	0	−2.12	1974	1
Japan	−2.20	3	−2.20	-	3
Netherlands	−1.75	1	−1.75	-	1
Norway	−2.55	1	−2.83	1974	1
Spain	−2.06	8	−2.06	-	8
Sweden	−2.74	3	−2.74	-	3
UK	−1.24	6	−1.24	-	6
USA	−2.36	0	−2.36	-	0
Panel LM test	−0.033			−2.627***	
Panel LM test omitting Finland				−1.572*	

Notes: The 1%, 5% and 10% critical values for the LM test without break are: −3.63, −3.06 and −2.77, respectively. The 1%, 5% and 10% critical values for the minimum LM test with one break are: −4.239, −3.566 and −3.211, respectively. The 1%, 5% and 10% critical values for the minimum LM test with two breaks are: −4.545, −3.842 and −3.504, respectively. The 1%, 5% and 10% critical values for the panel LM test (with or without breaks) are distributed asymptotic standard normal and are: −2.326, −1.645 and −1.282, respectively. *, **, and *** denote significant at the 10%, 5%, and 1% levels, respectively.

ABBREVIATIONS

ADF: Augmented Dickey-Fuller
DGP: Data Generating Process
IPS: Im, Pesaran and Shin, 1997
LM: Lagrange Multiplier
OECD: Organization for Economics Co-Operation and Development