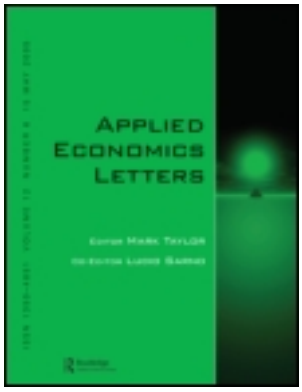

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Nonlinear vs. nonstationary of hysteresis in unemployment: evidence from OECD economies

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Nonlinear vs. nonstationary of hysteresis in unemployment: evidence from OECD economies

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This study examines the lower and higher boundaries for the threshold value to be considered an indicator of unemployment in a specific country. Specially, the objective is to conduct the critical moment of hysteresis effects happening in unemployment rate using a group of 16 organization for economic cooperation and development of countries. The methodological strategy applies a developed tool of threshold tests involving unit root against stationary but nonlinear alternative by Caner and Hansen (2001). A significant contribution of this study is identifying a trigger point from the nonstationary of time series process for the first time in the literature. Our empirical results finds strong evidence of the existence of nonlinear stationary in Australia, Canada, Finland, France, Germany, Ireland, Japan, Netherlands and the USA when the threshold effect holds. The hysteresis hypothesis is further confirmed by the fact that the unemployment rate exceeds the boundaries of the band, for Australia, Finland, France, Germany, Japan and the USA when the threshold unit root test of Caner and Hansen is rigorously implemented.

I. Introduction

In recent decades, numerous European Union (EU) economies have suffered from high level and persistence unemployment rates. The perspective of the traditional literature regarding the relationship between unemployment and business cycle can be divided into two parts. The first part, associated with the natural rate of unemployment or NAIRU, characterizes the dynamic behaviour of unemployment rate as reverting to the nature rate in the long-term. The natural rate of unemployment is thus determined by the equilibrium of the labour market. Another part, also known as the hysteresis hypothesis, which was pioneered by Blanchard and Summers (1986), states that cyclical fluctuations have permanent effects on the level of unemployment owing to labour market rigidity. Whenever evidence of hysteresis is found, there exists room to reduce unemployment without changing any labour market structures and the short-term adjustment of the economy may come up over a long period.

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Generally, these two theories regarding econometric approach can be verified based on the order of integration of unemployment. That is, evidence exists supporting the natural rate of unemployment under level stationarity, and the alternative hysteresis hypothesis holds given the existences of the unit root.

There is a vast body of empirical works that have attempted to test the existence of hysteresis in unemployment for developed countries. A brief review of the previous literature reveals three different groups of unit root tests. The first group of unit root tests generally involved applying the conventional unit root test of augmented Dicky–Fuller (ADF) or Phillips–Perron (PP) types to unemployment rates. (e.g. Neudorfer *et al*., 1990; Jaeger and Parkinson, 1994; Roed, 1996). These studies almost uniformly fail to reject unit roots in the EU unemployment rates because of the low power of these tests in the unit root null against the stationary alternatives, particularly when the root is near unity.

Thus, the second group uses a way of panel data of unit root tests to increase the power of tests based on a single time series. Intuitively, combining information from the time series dimension with that gain more power by exploiting the cross-sectional information and make inference more precise. Song and Wu (1997) use pooling data for organization for economic co-operation and development (OECD) countries and strongly reject the null that unemployment rate is a random walk process by Levin *et al*. (2002) tests. León-Ledesma (2002) also indicated that hysteresis is rejected for the US but supported for the EU while applying Im *et al*. (1997) approach. The latest approach developed by Camarero and Tamarit (2004), utilized two types of multivariate unit root tests, namely multivariate ADF (MADF) and seemingly unrelated regressions ADF (SURADF), proposed by Taylor and Sarno (1998) and Breuer *et al*. (1999) respectively, to demonstrate that 7 out of 19 OECD economies display evidence of hysteresis effects.

The third bulk of studies were considering the existence of a structural change in unemployment process. León-Ledesma (2004) used a panel stationarity test with multiple structural changes endogenously of the Carrion-I-Silvestre (2003) version of the test. The evidence give a dramatic remark when allow for structural breaks in the stationarity tests, hysteresis in unemployment is not only rejected in the panel, but the same as in the individual country tests and indicating that temporary shocks have persistent but nonpermanent effects on OECD unemployment rates.

However, to date the literature has failed to employ clear method of differentiating between nonlinearity and nonstationarity, despite structural unit root test being able to be treated as a special case of nonlinearity. Additionally, the above studies simply test for the existence of hysteresis in unemployment by adding power and searching structural breakpoint, and thus cannot accurately identify the moment of occurrence for policy-making purposes. To circumvent these problems, this study adopts a novel approach involving tests and distribution theories that were recently developed by Caner and Hansen (2001), and which enables for joint testing of nonlinearity and nonstationarity. This approach utilizes a two-regime symmetric threshold autoregressive (TAR) model with unit root, which allows for an inner disequilibrium and captures mean reversion in response to shocks outside the band. Within this model, this study examines the use of Wald tests for nonlinear adjustment and also examines the use of Wald and *t*-tests for nonstationarity.

This study contributes to the empirical note while the hypothesis of hysteresis in unemployment vs. the natural rate for 16 OECD economies while controlling for the possible existence of nonlinear behaviour by using Caner and Hansen (2001) threshold unit root tests. If this is the case, the usual unit root tests are subject to distortions resulting from size and lack of power that render them inadequate.

The remainder of this article is organized as follows. Section II is devoted to the econometric framework of the threshold autoregressive model with unit root in the unemployment rate; Section III then describes the data source and presents the empirical findings; Section IV reports the main conclusions.

II. Threshold Effect with Unit Root in Unemployment Rate

The model introduced by Caner and Hansen (2001) is a TAR process of the following form

$$\Delta U_t = \theta_1' x_{t-1} I_{\{Z_{t-1}<\lambda\}} + \theta_2' x_{t-1} I_{\{Z_{t-1}\geq\lambda\}} + e_t \quad (1)$$

where $x_{t-1} = \left(U_{t-1}, r_t', \Delta U_{t-1}, \ldots, \Delta U_{t-k}\right)'$, $I_{\{\cdot\}}$ is the indicator function, e_t is an i.i.d. error term, $Z_t = U_t - U_{t-m}$ for m represents the delay order and some $1 \leq m \leq k$. r_t is a vector of deterministic components including an intercept and possibly a linear time trend. The threshold value λ is unknown and takes the values in the compact interval $\lambda \in \Lambda = [\lambda_1, \lambda_2]$ where λ_1 and λ_2 are picked according to $P(Z_t \leq \lambda_1) = \pi_1 > 0$ and $P(Z_t \leq \lambda_2) = \pi_2 < 1$. It is

typical to treat π_1 and π_2 symmetrically so that $\pi_2 = 1 - \pi_1$, which imposes the restriction that no 'regime' has less than π_1% of the total sample. The particular choice for π_1 is somewhat arbitrary, and in practice must be guided by the restriction that no 'regime' needs to have sufficient observations to adequately identify the regression parameters. It is convenient to show the components of θ_1 and θ_2 as:

$$\theta_1 = \begin{pmatrix} \rho_1 \\ \beta_1 \\ \alpha_1 \end{pmatrix} \quad \text{and} \quad \theta_2 = \begin{pmatrix} \rho_2 \\ \beta_2 \\ \alpha_2 \end{pmatrix} \tag{2}$$

where $\rho_1, \rho_2, \beta_1, \beta_2$ are scalar and α_1, α_2 are $K \times 1$ vectors. (ρ_1, ρ_2) are the slopes on U_{t-1}, (β_1, β_2) are the slopes on the deterministic components and (α_1, α_2) are the slopes on dynamic regressors in two regime. Accordingly, we estimated Equation 1 by ordinary least squares (OLS) and then obtain σ^2 for fixed λ as $\hat{\sigma}^2(\lambda) = T^{-1} \sum_{t=1}^{T} \hat{e}_t^2(\lambda)$. The LS estimate of the threshold parameter is $\hat{\lambda} = \arg\min_{\lambda \in \Lambda} \hat{\sigma}^2(\lambda)$. In order to find estimates of slopes we plug in $\hat{\lambda}$ to have the slope estimates: $\hat{\theta}_1 = \hat{\theta}_1(\hat{\lambda})$ and $\hat{\theta}_2 = \hat{\theta}_2(\hat{\lambda})$. The estimated model can be written as follow:

$$\Delta U_t = \hat{\theta}_1' x_{t-1} I_{\{Z_{t-1} < \lambda\}} + \hat{\theta}_2'(\lambda) x_{t-1} I_{\{Z_{t-1} \geq \lambda\}} + \hat{e}_t \tag{3}$$

Next, we want to see whether there is nonlinearity in unemployment rates because of threshold effect. We set up the null as H_0: $\theta_1 = \theta_2$ which implies no threshold effect under null and sup Wald test $W_T = W_T(\hat{\lambda}) = \sup_{\lambda \in \Lambda} W_T(\lambda)$[1] is used for testing the null against the threshold model.

In Equation 1, the parameters ρ_1 and ρ_2 control the regime-dependent unit root process of the unemployment rate. A leading case is when unemployment rate is a unit root process such that H_0: $\rho_1 = \rho_2 = 0$. The standard test for the null above against the unrestricted alternative $\rho_1 \neq 0$ and $\rho_2 \neq 0$ is the Wald statistic, and expressed as $R_{2T} = t_1^2 + t_2^2$, where t_1 and t_2 are the t-ratios for $\hat{\rho}_1$ and $\hat{\rho}_2$ respectively from the least square of the TAR model. While it is unclear how to form an optimal one-sided Wald test, Caner and Hansen (2001) recommend focusing on negative values of $\hat{\rho}_1$ and $\hat{\rho}_2$ to end up with a simple one-sided Wald test statistic as $R_{1T} = t_1^2 I_{\{\hat{\rho}_1 < 0\}} + t_2^2 I_{\{\hat{\rho}_2 < 0\}}$ which is testing the unit root null hypothesis against the one-sided alternative $\rho_1 < 0$ or $\rho_2 < 0$. In general, Caner and Hansen (2001) suggest the individual t-statistic of t_1 and t_2 such that an insignificant t-statistic provides evidence in favour of the presence of a unit root in the TAR model. While the distributions of R_{1T} and R_{2T} have asymptotic approximations, improved finite sample inference may be conducted using a bootstrap distribution.

III. Data and Empirical Results

The data used in the analysis was obtained from the AREMOS Main Economic Indicators database of the Ministry of Education of Taiwan. The unemployment rates for 16 countries, namely Australia, Belgium, Canada, Denmark, Finland, France, Germany, Ireland, Japan, Luxembourg, Netherlands, Norway, Portugal, Sweden, the UK and the USA, during the study periods are summarized in the first column of Table 1.

As a benchmark, this study first applied several conventional unit root tests to the unemployment rates for individual countries. In Table 1, the null of the unit root (or hysteresis) cannot be rejected based on ADF test, except in the cases of Denmark, Portugal and the USA, and remains at a constant 10% level of significance, and the case of France, with a 5% level of significance. The KPSS test also yields similar results, and the PP indicates that all fail to reject the null unemployment for OECD economies. This finding is not surprising since these types of unit root test have lost almost their power when the alternative is nonlinear process.

The results of the estimation of threshold autoregressive model with unit root in the rates of unemployment are listed in Table 2. This study refers to the Wald statistic W_T for the estimating the threshold effect. In Table 2, the column for all of the coefficients tests shows strong evidence in 11 out of 16 OECD countries, with the exceptions of being the presence of significant threshold effect coming from the overall and ADF individual coefficient.

For one-side Wald tests of R_{1T} with unit root against a two-regime stationary nonlinear series, is rejected in nine countries (Australia, Canada, Finland, France, Germany, Ireland, Japan, Netherlands and USA) of the unit root null, favouring nonlinear stationary. Restated, these countries confirm the existence of the natural rate hypothesis from the perspective of nonlinearity. Under the presence of the threshold effect, Denmark and Portugal are also found to possess a nonlinear hysteresis effect.

[1] $W_T(\lambda) = T(\hat{\sigma}_0^2 / \hat{\sigma}^2(\hat{\lambda}) - 1)$ denotes the Wald statistic of the null of θ_1 equal to θ_2 for fixed λ and $\hat{\sigma}_0^2$ is the residual variances from OLS estimation of the null linear model. Then, since $W_T(\lambda)$ is a decreasing function of $\hat{\sigma}^2(\lambda)$, thus the Wald statistic for H_0 is often called the 'Sup-Wald' statistic.

Table 1. Univariate unit root test of the unemployment rate under level

OECD economies	Period	ADF	PP	KPSS
Australia	78:M2–05:M5	−2.053	−1.697	0.288
Belgium	82:M1–05:M4	−2.522	−1.500	0.585**
Canada	70:M1–05:M4	−1.996	−2.381	0.580**
Denmark	82:M1–05:M4	−2.824*	−1.437	0.710**
Finland	84:M1–05:M4	−1.993	−1.248	0.675*
France	82:M1–05:M4	−2.874**	−2.248	0.466*
Germany	78:M1–05:M4	−0.924	−1.233	1.403***
Ireland	82:M1–05:M4	−0.902	0.063	1.563***
Japan	70:M1–05:M4	−0.683	−0.720	2.038***
Luxembourg	82:M1–05:M4	−0.642	−0.104	0.373*
Netherlands	70:M1–05:M4	−2.085	−2.043	0.498**
Norway	89:M1–05:M3	−0.993	−0.838	1.116***
Portugal	83:M1–05:M4	−2.725*	−1.344	0.661**
Sweden	80:M1–05:M3	−1.561	−1.315	1.035***
UK	82:M1–05:M2	−1.197	−0.437	1.527***
USA	70:M1–05:M5	−2.809*	−2.547	0.656**

Notes: ***, **, * Indicate significance at the 1, 5 and 10% levels, respectively.

Table 2. Results of threshold unit root tests for unemployment rate

		Threshold effect tests (W_T)		Partial unit root				Threshold unit root	
OECD economies	Threshold value	Overall coefficients	Individual coefficient	t_1		t_2		$R_{1,t}$	
Australia	0.0023	46.2	(0.002)	27.9	(0.007)	3.47	(0.011)	−0.14	(0.824)	12.0	(0.052)
Belgium	0.0834	25.1	(0.440)	20.1	(0.214)	1.86	(0.332)	0.42	(0.749)	3.63	(0.656)
Canada	0.0738	35.1	(0.047)	21.8	(0.084)	1.07	(0.494)	4.65	(0.001)	22.8	(0.003)
Denmark	0.0670	31.9	(0.129)	26.2	(0.042)	1.46	(0.396)	1.69	(0.348)	4.99	(0.490)
Finland	0.0033	67.8	(0.001)	44.0	(0.003)	3.02	(0.075)	2.18	(0.195)	13.9	(0.072)
France	0.0855	32.3	(0.055)	20.3	(0.057)	3.13	(0.080)	1.48	(0.444)	12.0	(0.078)
Germany	0.0415	197.0	(0.007)	67.4	(0.022)	−12.1	(0.000)	0.10	(0.663)	145.0	(0.002)
Ireland	0.1606	34.4	(0.072)	14.1	(0.457)	0.12	(0.773)	−3.53	(0.023)	12.5	(0.065)
Japan	0.0178	47.7	(0.001)	29.1	(0.001)	5.92	(0.000)	−0.19	(0.840)	35.0	(0.000)
Luxembourg	0.0296	25.9	(0.263)	22.1	(0.113)	1.20	(0.485)	−0.56	(0.890)	1.75	(0.759)
Netherlands	0.0071	53.7	(0.094)	16.7	(0.171)	2.07	(0.241)	3.64	(0.068)	17.5	(0.096)
Norway	0.0366	18.6	(0.867)	12.9	(0.577)	1.56	(0.370)	0.77	(0.617)	3.02	(0.630)
Portugal	0.0640	24.5	(0.166)	17.4	(0.064)	0.65	(0.678)	−0.27	(0.839)	0.50	(0.942)
Sweden	0.0657	29.5	(0.112)	18.4	(0.188)	−0.83	(0.900)	1.05	(0.544)	1.77	(0.802)
UK	0.0645	27.3	(0.102)	17.7	(0.104)	−2.55	(0.990)	−0.21	(0.845)	6.55	(0.475)
USA	0.0037	60.5	(0.000)	24.3	(0.014)	3.75	(0.009)	0.57	(0.664)	14.4	(0.029)

Notes: Numbers in the parentheses are bootstrap p-values calculated by the 3000 replications.
Caner and Hansen (2001) have shown that the statistics of R_{1t} and R_{2t} have power against both alternatives, in order to save table space, here we only report the result of R_{2t}.

However, closely examining the results of the partial unit root test indicates that five countries accept the unit root null at a relatively low-unemployment regime (t_1) but reject it at alternative high regime (t_2). Note that, for instance, when the unemployment rate in France is below 8.55% the unit root (in favour of the natural rate of unemployment) is rejected; meanwhile, when the unemployment exceeds 8.55%, the null hysteresis hypothesis is accepted. Contradicting another condition, when the unemployment rate in Canada is below 7.38% (in regime one), the hysteresis hypothesis is accepted and then through labour policy revision or adjustment in the long-term will revert to the natural rate level at higher regime. The supportability of the hysteresis hypothesis under low regime may not arise in unemployment itself, we conjecture that this source could derive from the anxiety associated with the changing of the inflation or interest rate. To identify this answer will be investigated in the future.

IV. Conclusion

This study applied the Caner and Hansen (2001) threshold unit root tests to assess hysteresis in unemployment rate for a group of 16 OECD countries. This investigation unleashes a series of explorations of the decomposition of two-regime of the time series process itself. The result indicates that the nonlinear hysteresis hypothesis is supported in the cases of Denmark and Portugal. The partial unit root tests indicate that six countries support the natural rate hypothesis in the low-unemployment regime, but the cases of Canada, Ireland and Netherlands are in favour of natural rate and hysteresis under high regime contrary.

In relation to fiscal policy making, this outcome implies that once a trigger point is present in the unemployment process, it will have permanent effects and may cause the phenomenon of the revertible to the natural rate.

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