I. HYSTERESIS IN UNEMPLOYMENT FOR G-7 COUNTRIES: THRESHOLD UNIT ROOT TEST

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Abstract

In this empirical study, we apply the threshold unit root test proposed by Caner and Hansen (2001) to re-examine the hysteresis hypothesis in unemployment for G-7 countries over the period 1992M1 to 2008M9. The hysteresis in unemployment is confirmed for three countries, namely France, Germany and Italy when Caner and Hansen's (2001) threshold unit root test is conducted.

Keywords: hysteresis in unemployment, G-7 countries, Threshold Unit Root Test
JEL Classification: C22, E24

I. Introduction

The issue of unemployment clearly has become one of the most pressing problems for the countries around the world since the global financial crisis burst out in 2008. In the case of the U.S., the unemployment rate reached 10.6% in January 2010, a level not recorded since 1963. The Japanese unemployment rate in July 2009 has spiked to 5.7%, a level not recorded in more than five decades. The dominant feature of unemployment is its high persistence. What causes this higher persistence in unemployment has attracted a lot of both theoretical and empirical studies devoted to investigating whether the hypothesis of hysteresis in unemployment holds true for those countries with higher unemployment rates. These studies are critical not only for empirical researchers but also for policymakers.

Considering the assumptions inherent for the hysteresis hypothesis in unemployment, if unemployment is an I(1) process, then the shocks affecting the series will have permanent effects, thus shifting the unemployment equilibrium from one level to another.[2] Should this be the case, from the policy perspective, policy action is,

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[2] *Dixon and Shepherd (2001) point out that while it may be true that the unemployment series are stationary in the probability limit (here) one is dealing not only with a finite realization of the*

indeed, required to return unemployment to its original level. On the other hand, if unemployment is an I(0) process, the effects of the shock will merely be transitory, making the need for policy action less mandatory, since unemployment will eventually return to its equilibrium level. The I(0) process has commonly been referred to as the natural-rate of unemployment hypothesis (NAIRU), because it characterizes unemployment dynamics as a mean reversion process.[3]

Because hysteresis is associated with non-stationary unemployment rates, unit root tests have been used widely to investigate its validity. While empirical findings have generally supported a unit root in unemployment and, therefore, hysteresis, critics have claimed that the drawing of such conclusions may be attributed to the lower power of the conventional unit root tests employed when compared to near-unit-root but stationary alternatives.[4] In fact, the literature has documented that nonlinearities in unemployment rates are present due to cyclical asymmetries or idiosyncratic factors specific to the labor market (e.g., Peel and Speight, 2000; Caporale and Gil-Alana, 2007; Cancelo, 2007). It is not surprising that these factors should expectedly have cast considerable doubt on many of the earlier findings of a unit root in unemployment rates. Michael *et al*. (1997) claim that the Augmented DF test may lack power against stationary alternatives if the underling model is ESTAR instead of a standard, linear, autoregressive model. Enders and Granger (1998) also show that the standard tests for unit root all have lower power in the presence of misspecified dynamics. Sarno (2000) demonstrate that the adoption of linear stationarity tests is inappropriate for the detection of mean reversion if the true process of the data generation is in fact a stationary non-linear process. Juvenal and Taylor (2008) and Lothian and Taylor (2008) have argued that different speeds of adjustment at the disaggregated goods level average up to smooth nonlinearity at the aggregate level. An alternative view is that nonlinearity at the aggregate level is caused by other influences, such as the effects of official government intervention (Reitz and Taylor, 2008) or heterogeneous agents (Kilian and Taylor, 2003). Additionally, the existence of structure changes in

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process, but also a sample period that is 'very short'. In these circumstances, it is quite possible that the series may wander significantly within the interval, exhibiting characteristics that are, for all practical purposes, indistinguishable from an unrestricted random walk (see Smyth, 2003). Thus, the extant literature is followed and the issue of boundness is ignored in the present study.

[3] *If the unemployment rate exhibits hysteresis, then it follows a statistically non-stationary process, because the expected value of the unemployment rate now and in the future permanently shifts when the rate itself changes. The process with hysteresis is an I(1) process. This means that if unemployment is an I(1) process, then the shocks affecting the series will have permanent effects, thus shifting the unemployment equilibrium from one level to another or we can say form one state to another state and back is not done, unless we have strong power (either monetary or fiscal policy) to shift it back. At this moment, the unemployment becomes permanently higher after negative shocks. On the other hand, if the unemployment is an I(0) process, then the shocks affecting the series will only have temporary effects and back will be done without any strong power (either monetary or fiscal policy) on it. This means that the effects of the shock will merely be transitory, making the need for policy action less mandatory, since unemployment will eventually return to its equilibrium level.*

[4] *For example, see Caner and Hansen (2001), Gustavsson and Osterholm (2006), Ghosh and Dutt (2008), Yilanci (2008), and Lee (2010).*

unemployment might imply broken deterministic time trends and the result is a nonlinear pattern (Bierens, 1997). It should, therefore, not be unexpected that these shortcomings have seriously called into question many of the earlier findings based on a unit root in unemployment rates.

The central aim of this study contributes significantly to this field of research because, first of all, we examine the hysteresis in unemployment for G-7 countries using the threshold autoregressive model (hereafter, TAR) and the test statistics suggested by Caner and Hansen (2001). The main advantage of this procedure is that it allows one to test simultaneously for nonlinearities and nonstationarity. Secondly, to the best of our knowledge, this study is the first of its kind to utilize the threshold unit root test for hysteresis in unemployment in G-7 countries. This empirical study contributes to the field of empirical research by determining whether or not the unit root process is characteristic of unemployment in G-7 labor markets.

The remainder of this empirical note is organized as follows. Section II presents the data used, and Section III describes the methodology, the empirical findings and policy implications. Finally, Section IV presents some concluding remarks.

II. DATA

This empirical note employs the monthly unemployment rates for G-7 countries over the January 1992-September 2008 period. All the data are taken from the Datastream database and the summary statistics are given in Table 1.The unemployment data indicate that France and Japan have the highest and lowest average unemployment rates, respectively. The Jarque-Bera test results meanwhile indicate that, except for Germany, all the unemployment data sets are approximately non-normal. Figure 1 displays the time-series fluctuations in the unemployment rates in each country.

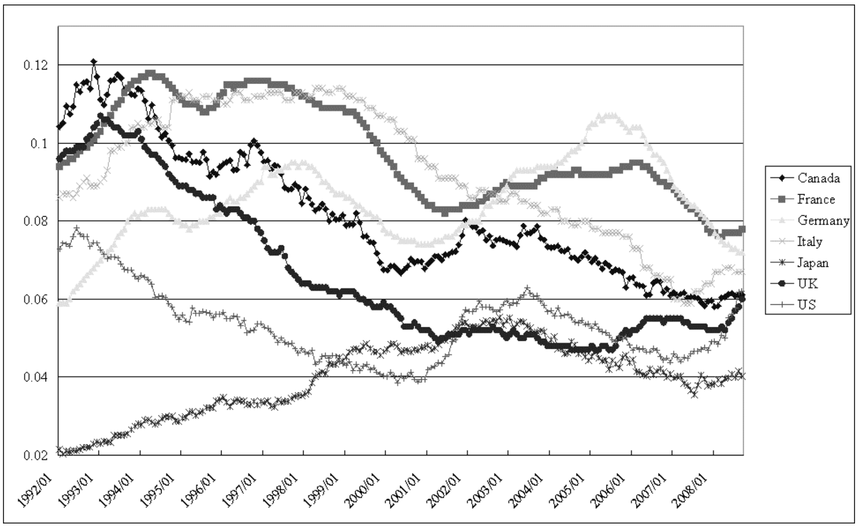
Table 1

Summary statistics of unemployment rates (raw data) for G-7 countries (1992M1-2008M9)

Statistic	Canada	France	Germany	Italy	Japan	UK	USA
Mean	0.0819	0.0981	0.0851	0.0927	0.0398	0.0663	0.0535
Median	0.0763	0.0940	0.0840	0.0910	0.0408	0.0570	0.0534
Maximum	0.1209	0.1180	0.1070	0.1140	0.0553	0.1070	0.0782
Minimum	0.0580	0.0760	0.0590	0.0590	0.0203	0.0470	0.0384
Std. Dev.	0.0171	0.0124	0.0107	0.0170	0.0095	0.0190	0.0094
Skewness	0.5878	0.0866	0.0372	-0.3259	-0.3040	0.8467	0.6619
Kurtosis	2.1898	1.6752	2.7261	1.8602	2.0931	2.1935	2.8800
Jarque-Bera	17.0742	14.9495	0.6747	14.4383	9.9836	29.4608	14.7967
Probability	0.0002	0.0006	0.7137	0.0007	0.0068	0.0000	0.0006
Observations	201	201	201	201	201	201	201

Figure 1

The tendency of unemployment rates (raw data) for G-7 countries (1992M1-2008M9)



III. METHODOLOGY AND EMPIRICAL RESULTS

A. Caner and Hansen's (2001) Threshold Unit Root Test

Following the work of Caner and Hansen (2001), we adopt a two regime threshold autoregressive (TAR(k)) model with an autoregressive unit root, as follows:

$$\Delta U_t = \theta_1' x_{t-1} I_{\{Z_t<\lambda\}} + \theta_2' x_{t-1} I_{\{Z_t\geq\lambda\}} + e_t, \quad t = 1, \dots, T \qquad [1]$$

where: U_t is the unemployment rate for $t = 1,2....,T$, $x_{t-1} = (U_{t-1}, v_t', \Delta U_{t-1}, \dots, \Delta U_{t-k})'$, $I_{\{\bullet\}}$ is the indicator function, e_t is an i.i.d. disturbance, $Z_{t-1} = U_{t-1} - U_{t-m}$ is the threshold variable, m represents the delay parameter and $1 \leq m \leq k$, v_t is a vector of exogenous variables 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 selected according to $P(Z_t \leq \lambda_1) = 0.15$ and $P(Z_t \leq \lambda_2) = 0.85$.[5] The components of θ_1 and θ_2 can be partitioned as follows:

[5] *According to Andrews (1993), this division provides the optimal trade-off between various relevant factors, which include the power of the test and the ability of the test to detect the presence of a threshold effect.*

$$\theta_1 = \begin{pmatrix} \rho_1 \\ \beta_1 \\ \alpha_1 \end{pmatrix} \qquad \theta_2 = \begin{pmatrix} \rho_2 \\ \beta_2 \\ \alpha_2 \end{pmatrix} \qquad [2]$$

where: ρ_1 and ρ_2 are scalar terms, β_1 and β_2 have the same dimensions as v_t, and α_1 and α_2 are *k*-vectors. Thus (ρ_1, ρ_2) are the slope coefficients on U_{t-1}, (β_1, β_2) are the slopes on the deterministic components, and (α_1, α_2) are the slope coefficients on $(\Delta U_{t-1}, \ldots, \Delta U_{t-k})$ in the two regimes.

The threshold effect in equation [1] has the null hypothesis of $H_0 : \theta_1 = \theta_2$, which is tested using the familiar Wald statistic: $W_T = W_T(\hat{\lambda}) = sup_{\lambda \in \Lambda} W_T(\lambda)$.[6] The stationarity of the process U_t can be established in two ways. The first is when there is a unit root in both regimes (a complete unit root). Here, the null hypothesis $H_0 : \rho_1 = \rho_2 = 0$ is tested against the unrestricted alternative $H_2 : \rho_1 \neq 0$ or $\rho_2 \neq 0$ using the Wald statistic. This statistic is:

$$R_{2T} = t_1^2 + t_2^2 \qquad [3]$$

Here, t_1 and t_2 are the t ratios for $\hat{\rho}_1$ and $\hat{\rho}_2$ from the least squares estimation. The parameters of ρ_1 and ρ_2 from equation [1] will control the regime-dependent unit root process of the unemployment rate. If $\rho_1 = \rho_2 = 0$ holds, then we say that the unemployment rate is I(1) and can be described as supporting "hysteresis in unemployment." Second, when there is a unit root in only one of the regimes, a case of partial unit root, the alternative hypothesis is of the form $H_1 : \rho_1 < 0$ and $\rho_2 = 0$, or $\rho_1 = 0$ and $\rho_2 < 0$. However, Caner and Hansen (2001) claim that the two-sided Wald statistic may have less power than a one-sided version of the test. As a result, they propose the following one-sided Wald statistic:

$$R_{1T} = t_1^2 I_{\{\hat{\rho}_1 < 0\}} + t_2^2 I_{\{\hat{\rho}_2 < 0\}} \qquad [4]$$

To distinguish between the stationary case given as H_1 and the partial unit root case given as H_2, Caner and Hansen (2001) suggest using individual t statistics t_1 and t_2. If only one of $-t_1$ and $-t_2$ is statistically significant, this will be consistent with the partial unit root case H_2. This means that unemployment behaves like a "nonstationary process" in one regime; but exhibits a "stationary process" in the other regime, vice versa. Caner and Hansen (2001) show that both tests R_{1T} and R_{2T} will

6 $W_T = W_T(\hat{\lambda}) = \sup_{\lambda \in \Lambda} W_T(\lambda) = T\left(\dfrac{\hat{\sigma}_0^2}{\hat{\sigma}^2(\lambda)} - 1\right)$, *where* $\hat{\sigma}_0^2$ *and* $\hat{\sigma}^2$ *are residual variances from least squares estimation of the null linear and TAR models, respectively.*

have power against both alternatives.[7] To obtain maximum power from these tests, critical values are generated using bootstrap simulations with 10,000 replications, as suggested by Caner and Hansen (2001).

B. Empirical Results

For comparison, we first apply several conventional unit root tests to examine the null of a unit root in the unemployment rate of each country. The results in Table 2 clearly indicate that both the ADF and the P-P tests fail to reject the null of non-stationary unemployment for all G-7 countries. The KPSS test also yields the same results. In other words, hysteresis in unemployment is confirmed for all G-7 countries under study. As stated earlier, there is a growing consensus that unemployment exhibits nonlinearities, and, consequently, conventional unit root tests such as the ADF test have low power in detecting the mean reversion of unemployment. Therefore, we proceed to test the hysteresis in unemployment by using Caner and Hansen's (2001) TAR unit root test.

Table 2

Univariate unit root tests

Country	Levels			First Differences		
	ADF	PP	KPSS	ADF	PP	KPSS
Canada	-0.8499 (0)	-0.8499 [0]	1.5615 [11]***	-15.0981 (0)***	-15.0981 [0]***	0.0757 [1]
France	-1.5478 (3)	-0.5416 [10]	1.2143 [11]***	-3.1186 (2)**	-9.0768 [8]***	0.3058 [10]
Germany	-2.4281 (3)	-2.2666 [10]	0.5258 [11]**	-3.7963 (2)***	-9.7174 [8]***	0.4351 [10]*
Italy	0.4030 (0)	0.2203 [5]	1.2674 [11]***	-13.5936(0)***	-13.7030 [5]***	0.9429 [5]***
Japan	-1.9885 (0)	-2.0303[9]	1.0838 [11]***	-16.3752(0)***	-16.4994 [4]***	0.6553 [8]**
UK	-2.0801 (0)	-1.6360 [8]	1.4678 [11]***	-6.5562(1)***	-11.1353 [6]***	0.6035 [8]**
US	-2.0617 (3)	-1.9543[7]	0.5853 [11]**	-5.3292 (2)***	-15.2016[7]***	0.4620 [7]*

*Note: ***, ** and * indicate significance at the 1%, 5% and 10% level, respectively. The number in parenthesis indicates the lag order selected based on the recursive t-statistic, as suggested by Perron (1989). The number in the brackets indicates the truncation for the Bartlett Kernel, as suggested by the Newey-West test (1987).*

First, we use the Wald test W_T to examine whether or not we can reject the linear autoregressive model in favor of a threshold model. The results of the Wald test along with the bootstrap critical values generated at conventional levels of significance are reported in Table 3. The bootstrap *p*-value for the threshold variables of the form $Z_{t-1} = U_{t-1} - U_{t-m}$ for delay parameters *m* varies from 1 to 24. Since the parameters *m* is generally unknown, there is no reason to assume the optimal delay parameter will be the same across countries. To circumvent this, Caner and Hansen (2001) suggest making *m* endogenous by selecting the least squares estimate of *m* that minimizes the residual variance. This amounts to selecting *m* at the value that maximizes the W_T statistic. We find that the W_T statistic is maximized for France and Italy when $m = 12$, for Germany when $m = 11$, for the UK when $m = 10$, for the

[7] *As stated by Caner and Hansen (2001) that R_{1T} has more power than that of R_{2T}, here we only report the results of R_{1T} in our study.*

US when $m = 2$, and for Japan when $m = 1$. Taken together, these results imply strong statistical evidence against the null hypothesis of linearity at least at 1% significance level in all G-7 countries, with the exception of France and the UK, and indicate that simple linear models are inappropriate and the TAR model is our preference.

Table 3

Threshold test

Countries	Wald Statistic	Bootstrap p-value	Optimal delay parameter m	Threshold parameter $\hat{\lambda}$	Number of observations in Regime 1 and its percentage
Canada	67.845	0.000	8	0.300	262(79.63%)
France	40.665	0.127	12	-0.400	88(26.74%)
Germany	59.515	0.000	11	-0.310	33(10.03%)
Italy	61.166	0.000	12	2.000	313(95.13%)
Japan	38.245	0.097	1	0.100	261(79.33%)
UK	41.112	0.163	10	0.200	202(61.39%)
USA	55.947	0.001	2	0.200	287(87.23%)

Note: Following much of the existing empirical literature on monthly unemployment, we set a maximum lag of 24 and base all our bootstrap tests on 10,000 replications. All of the statistics are significant, which supports the presence of threshold effects.

Next, we explore the threshold unit root properties of unemployment based on the R_{1T} statistic for each delay parameter *m*, ranging from 1 to 24, paying particular attention to the results obtained for our preferred model. The R_{1T} test results, together with the bootstrap critical value at the conventional levels of significance and the bootstrap *p*-value, are reported in Table 4. We are able to reject the unit root null hypothesis for Canada, Japan, the UK and the US at 10% significance level. Taken together, our results provide support for hysteresis in unemployment only for France, Germany and Italy.

Table 4

One sided unit root tests

Countries	Optimal delay parameter m	R_{1T} Statistic	Bootstrap critical values			Bootstrap p-value
			10%	5%	1%	
Canada	8	14.897	10.122	12.562	18.028	0.024
France	12	7.113	12.107	15.304	23.414	0.294
Germany	11	2.952	9.790	11.960	16.917	0.625
Italy	12	10.836	11.927	14.493	20.605	0.131
Japan	1	24.133	9.147	11.196	15.707	0.001
UK	10	14.799	12.134	16.028	27.261	0.062
USA	2	19.501	10.875	13.665	21.479	0.014

The one-sided test statistic of the R_{1T}, however, is not able to distinguish the complete and partial unit root in unemployment; we examine further evidence on the unit root hypothesis (partial unit root) by examining the individual t statistics, t_1 and t_2. The results are reported in Table 5. Also, with the exception of Canada, Japan, the UK and the US, the statistics for both t_1 and t_2 are smaller than the critical value at 5% level of significance, and this leads us to the conclusion that hysteresis in unemployment holds true only for France, Germany and Italy. Furthermore, we find that the US is the only country that exhibits stationarity in both regimes, supporting the natural-rate of unemployment hypothesis; however, for Canada, Japan, and the UK the natural-rate of unemployment hypothesis only holds true in one regime, since we find that partial unit root exists in these three countries.

Table 5

Partial unit root results

Countries	Optimal delay parameter m	t_1^2 statistic	Bootstrap p-value	t_2^2 Statistic	Bootstrap p-value
Canada	8	0.886	0.671	3.756	0.011
France	12	1.047	0.569	2.453	0.131
Germany	11	0.437	0.721	1.661	0.311
Italy	12	1.820	0.325	2.742	0.095
Japan	1	4.913	0.000	-2.267	0.281
UK	10	3.847	0.032	-0.105	0.827
USA	2	3.049	0.060	3.194	0.036

A major policy implication of our study is that a stabilization policy may have some permanent effects on the unemployment rates for only three of these G-7 countries under study. What, however, are the most effective policies to fight this continuously climbing unemployment? To answer this, the underlying reasons for unemployment must first be identified, but as this is beyond the scope of this paper, it will be investigated in a future study.

IV. CONCLUSIONS

In this empirical study, the threshold unit root test advanced by Caner and Hansen. (2001) was used to re-examine the hysteresis hypothesis in unemployment for the G-7 countries over the period 1992M1 to 2008M9. The hysteresis hypothesis in unemployment is confirmed for three countries, namely France, Germany and Italy when Caner and Hansen's (2001) threshold unit root test was conducted.

Finally, as concerns major policy, our study implies that a fiscal stabilization policy would possibly have permanent effects on the unemployment rates of France, Germany, and Italy.

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