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NON-LINEARITIES AND HYSTERESIS IN OECD UNEMPLOYMENT*

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ABSTRACT In this paper we test for the presence of unit roots in OECD unemployment controlling for the possibility that the unemployment rate shows a non linear behaviour. In order to do so, we make use of recently developed M-TAR tests for unit roots. Our results show that controlling for non linearities we can reject the null of strong hysteresis for Australia, Denmark, Portugal and the US. Overall, we find a higher degree of persistence after positive shocks hit the economy (i.e. shocks that reduce the unemployment rate). This is not consistent with matching theories of persistence.

Keywords: Unemployment Hysteresis, Unit Roots, M-TAR, Non-linearities.

JEL Classification: E24, C22.

Introduction

The dynamic behaviour of unemployment during the business cycle is a central part of empirical research in macroeconomics. The literature distinguishes between two main hypotheses. The first one states that output fluctuations will generate cyclical movements in the rate of unemployment that, in the long run, will tend to revert to its equilibrium value. This hypothesis, associated with the existence of a *natural rate* of unemployment (or NAIRU), characterises unemployment dynamics as a mean reversion process. The second hypothesis, the so-called unemployment *hysteresis*, defends the view that cyclical fluctuations will have permanent effects on the level of unemployment due to labour market rigidities. Thus, under this hypothesis – pioneered by Blanchard and Summers (1986) – the level of unemployment is characterised as a non-stationary or unit root process. The existence of hysteresis should not be confused with *persistence*. In this case, although the speed of adjustment towards the equilibrium level is slow, unemployment shows mean reversion. Thus, persistence is a special case of the natural rate hypothesis in which unemployment is a near-unit root process. Under hysteresis, macroeconomic policy would have permanent effects on unemployment. If persistence were the prevailing case it would have long lasting but not permanent effects.

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Several works have attempted to test the presence of hysteresis in unemployment for developed countries as in Blanchard and Summers (1986), Mitchell (1993), Brunello (1990), León-Ledesma (2002) and Song and Wu (1997) and for transition economies as in León-Ledesma and McAdam (2002). In general, the studies cannot reject the null of a unit root for most of the European countries but the results for the US are mixed. On the other hand, there is increasing evidence that macroeconomic time series are best represented by non-linear processes[2]. This sort of non-linearity is usually represented by a Threshold Autoregressive (TAR) process, where the autoregressive behaviour of the process depends on previous realizations of the series or its first difference. These TAR models – see Tong (1983) – have led to an offspring of works that try to adapt unit root or near unit root tests to the presence of non-linear or asymmetric behaviour. Important references in this area are Enders and Granger (1998), Enders (2001), Caner and Hansen (2001) and Shin and Lee (2001).

In this paper, we test for the presence of unit roots in unemployment rates of 12 OECD countries controlling for the possible existence of a non-linear behaviour in the series. If non-linearities exist, the usual unit root tests would be subject to lack of power and size distortions that render them inadequate. In the next section we present a theoretical model of hysteresis. In section 3 we explain the testing procedure and results and section 4 concludes.

The model

Based on León-Ledesma (2002), we present a simple insider-outsider model of the labour market to derive our empirical analysis. Although unionisation is not the only factor determining the existence of slow labor market adjustment to shocks, the model will be sufficient to show how institutional factors may lead to hysteresis. According to this theory, hysteresis may arise as a consequence of the division between insider workers (currently employed) and outsiders (unemployed). Insiders are unionised or simply have all the bargaining power due to the fact that they have firm-specific skills. 'Outsiders are disenfranchized and wages are set with a view to insuring the jobs of insiders. Shocks which lead to reduced employment change the number of insiders and thereby the subsequent equilibrium wage rate, giving rise to hysteresis' (Blanchard and Summers, 1986). Let y_t be aggregate demand, m_t money supply and p_t the price level[3]. Demand depends on real money balances:

$$y_t = c \cdot (m_t - p_t) \tag{1}$$

Production is constant returns to scale and only uses labour (n_t). Since $y_t = n_t$ then profit maximisation leads to $p_t = w_t$, where w_t is the nominal wage. Insiders expect employment to be a function of the past period employment so that $n^E_t = \phi \cdot n_{t-1}$, with $0 < \phi \leq 1$. In equilibrium, aggregate supply equals demand and we have,

$$n_t = c \cdot (m_t - w_t). \tag{2}$$

2 See the pioneering work of Neftci (1984) and, for instance, Potter (1995) for GDP series and Peel and Speight (1998) for unemployment rates.

3 All the lower case variables are expressed in logarithms.

Taking expected values and subtracting from (2) we get

$$n_t - n_t^E = c\cdot(m_t - m^E{}_t) - c\cdot(w_t - w^E{}_t). \tag{3}$$

Since wages are set by the union in advance, $w_t = w^E{}_t$, and the union's expectations are such that $n^E{}_t = \phi\cdot n_{t-1}$ we can write

$$n_t = \phi\cdot n_{t-1} + c\cdot(m_t - m^E{}_t). \tag{4}$$

The term in brackets, the unexpected shocks to money supply, can be considered to be random or unexplainable and hence $n_t = \phi\cdot n_{t-1} + \varepsilon_t$, where ε_t is an i.i.d. error term. From this, we can see that employment –and unemployment if labour supply is stationary– follows a random walk with shocks affecting on a permanent basis, if and only if $\phi = 1$[4]. Otherwise the model would predict persistence.

The size of ϕ could be different depending on the state of the business cycle. Positive and negative shocks to unemployment in the previous year may have different effects on the insiders' capacity to keep employment constant after a shock. For instance, if there is a negative shock affecting unemployment ($\Delta u_t > 0$), the size of outsiders would increase. According to unionization theories, the size of the union would now be smaller, which will weaken its bargaining position. We would then expect that ϕ would be smaller than 1 after a negative shock and closer to 1 after a positive one. That is, persistence would be higher after positive shocks to the economy (negative shocks to unemployment, $\Delta u_t < 0$). On the other hand, matching models in the spirit of Pissarides (1992) would predict that persistence is higher after a negative shock due to the fact that workers loose skills when unemployed that reduce the probability of job-vacancy matching. Hence, these two theories of persistence would have different non-linear behaviours. The advantage of using non-linear tests of unit roots, hence, does not only rest on their statistical properties, but also on their possible theoretical implications.

Empirical procedure and evidence

Let $u_{i,t}$ be the unemployment rate of country in time $t = 1, 2, \ldots T$, then the dynamics of unemployment can be represented by the following ADF(p_i) regression:

$$\Delta u_t = \mu + \beta t + \rho u_{t-1} + \sum_{j=1}^{p} \gamma_j \Delta u_{t-j} + \xi_t \tag{5}$$

The usual way to test for hysteresis is by testing the null hypothesis $\rho = 0$. This ADF test, however, assumes that unemployment follows a linear representation. If however, unemployment is non-linear in the business cycle, we can use the following TAR representation (Caner and Hansen, 2001):

$$\Delta y_t = \theta_1' y_{t-1} 1_{\{z_{t-1} < \lambda\}} + \theta_2' y_{t-1} 1_{\{z_{t-1} \geq \lambda\}} + \sum_{j=1}^{p} \gamma_j \Delta u_{t-j} + \zeta_t\ , \tag{6}$$

[4] That is, in case that the insiders' objective is to maximise wages keeping the size of the union constant.

where $y_{t-1} = (1\ t\ u_{t-1})$, $1_{\{.\}}$ is the indicator function that takes the value of 1 if z_{t-1} is higher or lower than a threshold λ, and 0 otherwise. The variable z_t is any stationary variable that would determine the change of regime. For our purposes, we set $z_t = u_t - u_{t-m}$. That is, we assume that unemployment may have a different behaviour depending on whether past *changes* in unemployment have been higher or lower than a certain threshold λ. This is a momentum-TAR model or M-TAR as in Engle and Granger (1998). The lag length *m* for the changes in unemployment will be data determined as will be the search for the optimal threshold λ. Finally, the parameter vectors θ_1 and θ_2 can be partitioned as

$$\theta_1 = \begin{pmatrix} \mu_1 \\ \beta_1 \\ \rho_1 \end{pmatrix}, \qquad \theta_2 = \begin{pmatrix} \mu_2 \\ \beta_2 \\ \rho_2 \end{pmatrix}$$

The choice of the threshold λ could be simply made on an a priori basis, such as setting $\lambda = 0$ or equal to the sample mean of Δu_t. However, this would be a biased estimate of the threshold if asymmetric adjustment exists and a subjective measure of the non-linearity threshold. In order to search for the optimal threshold, we follow Chan (1993) and find λ as the value of Δu_t that minimises the residual sum of squares of the OLS estimation of (6)[5].

In order to test for the existence of asymmetry in the adjustment under both regimes we test the null hypothesis $H_o : \theta_1 = \theta_2$ on the OLS estimation of (6), making use of a Wald statistic. The hysteresis or unit root hypothesis would imply testing H_o: $\rho_1 = \rho_2 = 0$, and we also make use of a Wald statistic and an F statistic. Finally, in order to choose *m*, the lag length for the change in unemployment that determines asymmetry, we also chose *m* to minimise the residual sum of squares. Given that the Wald test of asymmetry is a monotonic function of the residual variance, we choose *m* as the value which maximizes the Wald test of asymmetry.

The steps followed to test simultaneously for asymmetry and unit roots are as follows:

- *Step 1.* Estimate a baseline model for the linear ADF regression to determine the lag augmentation of the DF regression using general-to-specific techniques.
- *Step 2*. Select the threshold by minimising the residual sum of squares as mentioned earlier. Fit M-TAR model by OLS for every value of *m*. Choose the *m* that minimises the residual sum of squares[6].
- *Step 3*. Test for unit roots using the Enders-Granger (1998) F-test (F_{EG}) and compare its value with the newly tabulated critical values of Enders (2001). We can also test for unit roots using the Caner and Hansen (2001) Wald test (R_{CH}), which we compare with the upper bound 10% critical level tabulated by Caner and Hansen.
- *Step 4*. If the variables are shown to be I(0), we can apply a normal F-test for asymmetry. However, if they are I(1), we test for asymmetry by using the Caner and Hansen (2001) asymmetry Wald test (W_{CH}). We compare its value with the 10% asymptotic critical value tabulated in the aforementioned paper.
- *Step 5*. If we find asymmetry, then the process stops here. If we do not find asymmetry, then we have to trust the results of the linear ADF test because of its higher power and reduced size distortions (see Enders, 2001).

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5 In practice we eliminated the highest and lowest 10% values of ?$u_{t.}$

6 Usually, for monthly data we take m = 1,…, 12 and for quarterly m = 1,…, 4.

We applied unit root tests to the unemployment rates of a set of 12 OECD countries namely Australia, Canada, Denmark, Spain, France, UK, Italy, Japan, The Netherlands, Portugal, USA and West Germany. We use quarterly data up until 2002:1 and starting where data was available. Starting dates range from 1960:1 for several countries to 1983:1 for Portugal. In general, we have around 35 years of data for each country. The data used is the standardized unemployment rate from OECD's Quarterly Labour Statistics.

The results of the baseline ADF tests are provided in Table 1 together with the estimation period and the lag augmentation chosen by general-to-specific methods. As we can see, for none of the countries we can reject the null of a unit root. It is well know that ADF tests lack power and, hence, tend to accept the null when the alternative is true. Methods such as panel unit-roots tests have been recently proposed to control for this problem. However, we want to see if, at least partly, asymmetric adjustment is responsible for this result.

The results of the estimation of the non-linear M-TAR model are reported in Table 2. We used the same augmentation lag as in the ADF tests as explained earlier. The table provides the optimal threshold for Δu_{t-m}, the optimal differentiation lag m, the estimates of the parameters of the model under both regimes and two tests of asymmetry and another two for unit roots. The asymmetry tests are the Caner and Hansen (2001) Wald test (W_{CH}) and a simple F statistic for testing asymmetry only in the persistence parameter ρ (F_{pers}). The unit root tests are the F test of Enders and Granger (1998) (F_{EG})[7] and the Wald test of Caner and Hansen (2001) (R_{CH}). The parameters with the subscript 1 represent the parameters of the model when $\Delta u_{t-m} > \lambda$, that is, after a negative shock that increases unemployment above the threshold. The other way round occurs for parameters with subscript 2. The optimal threshold differs substantially between countries. This is due to the fact that for some countries increases in unemployment dominate the series while, for others, unemployment decreases more often. It is also due to the different m values obtained.

Overall, we can see that symmetry can be rejected for 6 countries using the R_{CH} test, and for another 6 countries using the F_{pers} test. In some cases, such as Spain, The Netherlands and West Germany, asymmetry arises because of the difference in constants and time trends. In other cases, such as France, the UK, Japan and the USA there is evidence of asymmetric persistence, but we cannot reject the null of joint asymmetry by the W_{CH} test. When this asymmetry is accounted for, we can now reject the null of a unit root clearly in four cases: Australia, Denmark, Portugal and the USA. For the UK there is evidence of stationarity using the F_{EG} test, but not with the R_{CH} test. For Spain, The Netherlands and West Germany asymmetric behaviour does not lead to a rejection of the null of a unit root. For the rest of countries where no evidence of asymmetric adjustment is shown, we have to rely on the ADF tests of Table 1.

An interesting feature arises when analyzing the values of the persistence parameter under the two regimes. In 8 out of 12 cases the speed of adjustment is higher in regime 1 than in 2. That is, unemployment tends to revert quicker to the mean when negative shocks affect the economy (positive shocks to the unemployment rate or, at least, above the threshold). As discussed in the theory section, this behaviour would not be compatible with matching theories arguing that persistence is higher after an increase in unemployment. It is difficult, however, to categorically support unionisation theories given that they are not the only alternative and, most importantly, given the reduction in the degree of unionisation of these economies during a good part of the period considered.

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[7] As mentioned earlier, we compare this test with the critical values of Enders (2001).

Conclusions

In this paper we have tested for the existence of unit roots in the unemployment rates of 12 OECD economies to test for hysteresis versus the natural rate hypothesis. We make use of recently developed tests for unit roots that take into account asymmetric adjustment of the series during the business cycle (M-TAR models). Our results show that unemployment rates in 9 out of these countries show features of asymmetric adjustment. This is especially so for Australia, Denmark and Portugal. Once we control for these asymmetries, we can reject the null of a unit root or hysteresis for Australia, Denmark, Portugal, the USA and, marginally, the UK. For the rest of European countries and Japan, we cannot reject hysteresis. Finally, the speed of adjustment tends to be faster when negative shocks affect the economy, which runs against the conclusions of some matching theories of aggregate unemployment persistence.

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Table 1**. ADF tests on unemployment rates.**

Country	**Period**	Lag	ADF
Australia	1967:1-2002:1	2	-2.437
Canada	1960:1-2002:1	1	-1.933
Denmark	1970:1-2002:1	1	-2.275
Spain	1964:2-2002:1	4	-2.142
France	1967:4-2002:1	1	-1.772
UK	1960:1-2002:1	1	-2.288
Italy	1960:1-2002:1	5	-1.403
Japan	1960:1-2002:1	3	-1.245
Netherlands	1970:1-2002:1	1	-1.707
Portugal	1983:1-2002:1	3	-2.422
USA	1960:1-2002:1	4	-2.216
West Germany	1965:2-2002:1	4	-2.176

Table 2**. M-TAR model for unemployment rate.**

Country	*AUS*	*CAN*	*DEN*	*SPA*	*FRA*	*U.K.*	*ITA*	*JAP*	*NET*	*POR*	*USA*	*WGER*
λ	0.59	-0.04	1.73	0.52	-0.30	0.17	-0.26	0.04	0.16	-0.90	0.36	-0.30
m	1	1	4	2	1	1	2	2	1	2	1	1
μ_1	-0.268 (-0.839)	0.138 (1.132)	-2.073 (-2.282)	-0.269 (-0.603)	0.048 (1.163)	-0.044 (-0.686)	0.300 (1.902)	-0.018 (-0.569)	0.725 (3.803)	0.668 (2.394)	0.774 (3.354)	0.408 (2.519)
μ_2	0.115 (1.665)	0.255 (2.152)	0.280 (2.215)	1.112 (3.939)	0.689 (1.629)	0.054 (2.026)	-0.195 (-0.718)	-0.030 (-0.844)	0.155 (1.302)	0.322 (-0.669)	0.164 (1.813)	-0.636 (-2.563)
β_1	0.015 (3.435)	0.001 (1.217)	0.083 (3.752)	0.134 (1.762)	0.001 (0.465)	0.003 (3.103)	0.003 (1.316)	0.002 (2.608)	-0.003 (-1.428)	-0.003 (-1.830)	-0.000 (-0.174)	0.001 (0.299)
β_2	0.000 (0.373)	0.001 (1.527)	-0.002 (-1.491)	-0.011 (-3.856)	-0.354 (-1.595)	-0.000 (-0.475)	-0.002 (-0.902)	-0.000 (-0.428)	-0.001 (-1.270)	0.211 (0.683)	0.000 (0.431)	0.006 (1.222)
ρ_1	-0.170 (-3.297)	-0.037 (-1.685)	-0.587 (-4.553)	-0.025 (-0.816)	-0.010 (-0.874)	-0.032 (-2.545)	-0.058 (-1.460)	-0.044 (-1.727)	-0.023 (0.759)	-0.056 (-3.020)	-0.087 (2.863)	-0.028 (-0.596)
ρ_2	-0.022 (-1.416)	-0.044 (2.336)	-0.006 (-0.430)	0.005 (0.352)	-1.155 (-1.815)	-0.009 (-1.836)	0.033 (0.594)	0.030 (0.979)	-0.023 (1.639)	-0.001 (0.236)	-0.035 (-2.355)	-0.107 (-1.425)
W_{CH}	11.559	1.288	21.992	22.567	5.406	10.334	8.093	5.423	22.010	23.071	10.445	25.820
Fpers	7.747	0.070	20.402	0.804	3.244	2.946	1.830	3.439	0.000	9.121	6.328	0.753
F_{EG}	6.309	4.182	10.367	0.401	1.945	4.754	1.265	1.965	1.651	9.455	6.938	1.232
R_{CH}	12.619	8.363	20.733	0.802	3.889	9.509	2.531	3.930	3.303	18.911	13.875	2.465
lag	2	1	1	4	1	1	5	3	1	3	4	4

Notes: T-rations in parentheses. Bold indicates that the test is significant at the 10% level.