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Testing for hysteresis in unemployment in OECD countries. New evidence using stationarity panel tests with breaks*

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Abstract

This paper tests hysteresis effects in unemployment using panel data for 19 OECD countries covering the period 1956-2001. The tests exploit the cross-section variations of the series, and additionally, allow for a different number of endogenous breakpoints in the unemployment series. The critical values are simulated based on our specific panel sizes and time periods. The findings stress the importance of accounting for exogenous shocks in the series and give support to the natural-rate hypothesis of unemployment for the majority of the countries analyzed.

JEL Classification: C22, C23, J64

Keywords: Hysteresis, panel unit root tests, structural break

Resum

En aquest treball es contrasta la hipòtesi d'histèresi en la taxa d'atur emprant un panell de dades format per 19 països de l'OCDE en el període 1956-2001. El contrast fa ús de la variació de tall transversal i, addicionalment, permit la presència de múltiples canvis estructurals en les sèries d'atur, canvis que es fixen de manera endògena. Els valors crítics se simulen atenent a les especificitats del panell de dades. Els resultats revelen la importància de tenir en compte el fet de les pertorbacions exògenes en les sèries i mostren com la hipòtesi de la taxa natural d'atur pot explicar el comportament de la variable per a la majoria dels països analitzats.

Classificació JEL: C22, C23, J64

Paraules clau: Histèresi, contrastos d'arrels unitàries en panells de dades, canvis estructurals

1. Introduction

Although labour markets in Europe show a high degree of heterogeneity in terms of levels of unemployment and market rigidity, the presence of hysteresis or, at least the high degree of persistence in the evolution of unemployment in the European Union (EU) members compared to other OECD countries is a common European feature. The most commonly used explanation for persistence is that rigidities of the European labour markets cause unemployment, especially compared to the North American more flexible one. This view was supported by a first generation of empirical studies based on time series techniques, concluding that the hysteresis hypothesis could only be rejected for the US, but not for the majority of EU members.

This is an issue of special concern in an economically integrated area. More specifically, in a monetary union, differences in the behaviour of economic agents in the face of similar shocks may be an important source of asymmetric effects of common shocks. This is particularly true for wage behaviour due to its central role in the determination of inflation, real exchange rates and unemployment. Different degrees of real wage rigidity will imply different effects on unemployment. Therefore, there has been an increasing pressure during the 80's and the 90's[1] to undertake measures aiming at the building of more flexible labour markets. Labour market and employment policies refer to the actions of government, employers and trade unions in setting the framework for functioning labour markets and in negotiating wage settlements. Greater labour market flexibility and, where appropriate, reform of wage formation systems so that these better reflect local productivity and labour market conditions, would be important steps to tackle the high rates of structural unemployment which still persist in

[1] Since 1997 there is a formal co-ordination procedure commonly known as the "Luxembourg process", which main policy instrument is the annual Employment Guidelines that set out recommendations that are transposed into policy proposals through the National Employment Action Plans (ECB, 2001).

a number of Member States. Even if some progress has been accomplished in these areas, the launching of the monetary union has made more urgent to remove rigidities and perverse incentives in labour markets. The expected outcome of these institutional changes should be a reduction in the degree of persistence of unemployment rates in the EU.

From a theoretical point of view, we can distinguish two main hypotheses relating unemployment and the business cycle. The first one, the so-called "natural" rate of unemployment or NAIRU, characterizes unemployment dynamics as a mean reverting process, which means that in spite of cyclical movements, the unemployment rate tends to revert to its equilibrium in the long run. The second one, also known as the "hysteresis" hypothesis, states that cyclical fluctuations have permanent effects on the level of unemployment due to labour market rigidities and, therefore, the level of unemployment can be characterized as a non-stationary process. It is worth to note that there is a crucial difference between the concepts of "hysteresis" and "persistence". Persistence implies a slow speed of adjustment towards the long run equilibrium level, and therefore, is a special case of the natural rate of unemployment hypothesis, as the series show mean reversion after all. From an econometric point of view it can be characterized by a near unit root process. If this is the case, macroeconomic policy would have long lasting but not permanent effects while, conversely, if hysteresis applies, the effects on unemployment are permanent. Sometimes the existence of persistence might be hiding changes in the level of the natural rate. This possibility has been pointed out by the structuralist view of the natural rate of unemployment (Phelps, 1994).

All these hypotheses can be easily tested in a framework based on the theory of cointegration. The contributions of this paper to this literature are twofold. First, we test for unit roots in unemployment in a panel context using the test procedures proposed in the recent econometric literature both under the null of unit root as in Im, Pesaran and Shin, (1997)[2] and Maddala and Wu (1999) and under the null of stationarity as in Hadri (2000). These tests allow us to consider a higher degree of heterogeneity in the cross-section dynamics and show higher power than their time series equivalents. Secondly, we apply the panel unit root tests developed by Carrion-i-Silvestre et al. (2003) that test for stationarity in the presence of structural change finding much stronger rejections of unit roots. The purpose of the paper is to test for the hysteresis hypothesis versus the natural rate of unemployment, considering the possibility of structural change in the level of the series of unemployment. We use a relatively long sample from 1956 to 2001 of annual data that includes the EU countries plus some other OECD members.

The remainder of the paper is organized as follows. Section 2 provides an overview of the theoretical and recent empirical literature on the issue of unemployment persistence for the EU case. Section 3 briefly describes the tests used in the paper, and the econometric results. Finally, in section 4 we report the main results and conclusions.

2. A short overview of theory and recent empirical literature

The concept of hysteresis in unemployment was first introduced by Phelps (1972) denoting situations where transitory shocks have permanent or very persistent effects on the unemployment rate. Hysteresis can arise due to labour market rigidities as introduced by insider-outsider interactions (Blanchard and Summers, 1986) or human-capital effects (Layard et al., 1991).

According to the structuralist school the natural rate is endogenous and affected by market forces like any other economic variable (Pissarides, 1990, Layard et al., 1991) giving rise to autonomous movements of the natural rate due to changes either in real macroeconomic variables as real interest rates (Blanchard, 1999), rate of productivity growth (Pissarides, 1990), oil prices (Oswald, 1999) and stock

[2] IPS hereafter.

prices (Phelps, 1999) or in the institutional framework such as the generosity of the unemployment-benefit welfare system, other forms of nonwage income, the family network, and the (consumption) tax wedge. The structuralist view would be in line with the existence of structural breaks of the steady-state path of a stochastic stationary process while hysteresis or persistence would be consistent with unit-root or near-unit root, processes, respectively. From a theoretical point of view, the slow adjustment process to that equilibrium is modelled by introducing real-wage rigidity through, for example, efficiency-wage or union behaviour models.

In a brief review of the empirical literature, we can find three different groups of studies based on the type of unit root test used. A first one would consider the papers that apply classical unit root tests (basically ADF- type). The results of these studies applied to EU countries seem to be quite conclusive. Using a wide variety of techniques and sample frequencies and periods, they almost uniformly fail to reject unit roots in the unemployment rates, suggesting that unemployment rates in Europe are nonstationary (Mitchell, 1993 and Roed, 1996). Conversely, the evidence for the US is mixed as some studies conclude that US unemployment is nonstationary (Mitchell, 1993, Breitung, 1994 and Tanaka, 1996) while others find that US unemployment rate is stationary (Nelson and Plosser, 1982, Perron, 1989, Roed, 1996 and Xiao and Phillips, 1997). One factor affecting the rejection or nonrejection of the unit root hypothesis seems to be the lag specification (Roberts and Morin, 1999).

A second bulk of studies consider the existence of a structural change in the individual series of unemployment rate. The seminal work of Perron (1989) shows that in the presence of a structural break, standard unit root tests are biased towards the nonrejection of a unit root and has inspired an extensive research agenda on testing for unit roots in the presence of structural change. Banerjee, Lumsdaine, and Stock (1992), Zivot and Andrews (1992) and Perron

(1997), among others, develop tests which allow for a break to be endogenously determined, and Lumsdaine and Papell (1997) extend the tests to allow for two breaks. The equilibrium rate of unemployment may change due to permanent supply side shocks or institutional regulation reforms in the labour markets. It is now commonly accepted that the non rejection of the unit root hypothesis may be caused by mis-specification of the deterministic components. Using this type of tests, the results show a clearer trend to reject the nonstationarity of the series (Arestis and Mariscal, 1999, Papell et al, 2000, Ewing and Wunnava, 2001 or Johansen, 2002).[3]

A third group of empirical studies are based on the recent panel unit root tests. Starting with Levin and Lin (1992) test (LL), much work has also been done on testing for unit roots in panels, including the IPS test developed by Im, Pesaran and Shin (1997) or the test proposed by Hadri (2000). Song and Wu (1997, 1998) strongly reject a unit root in the unemployment rate for US states using LL test and León-Ledesma (2000) is also able to reject hysteresis for the US but not for the EU using the IPS tests. However, it is worth to note that when there is cross-sectional dependence in the disturbances none of these tests are no longer applicable[4]. Strazicich et al. (2001) apply the Im and Lee (2001) panel LM unit root test, that allows for heterogeneity in the persistence parameter and up to two possible level shifts. This panel LM unit root test outperforms the Dickey-Fuller type panel unit root tests with breaks because the asymptotic distribution of the panel LM test is invariant to the presence of level shifts. Although their results indicate

[3] Closely related to the existence of discontinuities in the series is the fact of nonlinearities in unemployment that can affect the results of unit root tests. Empirical studies of the business cycle have found evidence of asymmetries in unemployment (see Sichel, 1993, Peel and Speight, 1995, and Koop and Potter, 1998). However, the analysis of the asymmetric nature of the dynamic adjustment goes far beyond the purpose of the present paper.

[4] León-Ledesma (2000) finds a high degree of cross-country correlation in unemployment, and hence he addresses this problem adjusting the data in an ad-hoc manner by substracting the cross-sectional averages. This correction is however defficient because it partially removes the information content in the data.

that the hysteresis hypothesis is rejected for OECD countries, the test imposes the absence of cross-correlation in the error terms which is, in our opinion, a quite restrictive assumption and contradicts the empirical findings of previous studies[5]. Finally, Murray and Papell (2003) study hysteresis in unemployment for a sample of 17 OECD countries for the period 1955-1990 using an ADF-type panel unit root test for non trending data allowing for a one-time change with heterogeneous intercepts. Using Monte Carlo methods, the critical values are computed accounting for both serial correlation and cross correlation in the residuals. They find very strong evidence of regime-wise stationarity for the full panel of OECD countries as well as for a number of smaller sub-panels (European, EFTA and EC countries). However, the span of the sample is short due to the consideration of just one time change. Therefore, in their paper, they suggest a very challenging research agenda to extend their work considering multiple breaks and/or trending data. In the present paper we try to address these suggestions as well as to overcome the relevant flaws that appear in the previous empirical literature.

3. Empirical results

The contributions of this paper are twofold. First, we apply the IPS tests and Maddala and Wu (1999) panel unit root tests jointly with the Hadri (2000) stationarity test. To the best of our knowledge, this is the first time that the latter test has been used in the empirical literature on hysteresis in unemployment. The conventional time series unit root tests have poor power properties in distinguishing the unit root null from stationarity alternatives, particularly when the root is close to unity. Therefore, there is a recent literature based on tests with the opposite null hypothesis, that is, stationarity. Although these tests have more power, generally seem to have poor size properties (*i.e.* they reject

[5] See León-Ledesma (2000) above.

stationarity too often), especially if the variable has some degree of persistence, which unfortunately is the case with the unemployment rate series. This flaw can be corrected to some extent in a panel context as we do in our paper. Intuitively, combining information from the time series dimension with that obtained from the cross-sections will increase the sample size and therefore make inference more precise. Secondly, we apply the Carrion-i-Silvestre et al. (2003) test incorporating structural changes endogenously determined in a panel context, which improves largely the power of the time series test used in Papell et al. (2000). Additionally, this test allows for multiple number and type of breaks and accounts for cross-correlation in the residuals, solving the main drawbacks in panel studies above mentioned.

3.1 Panel data unit root and stationarity tests without structural breaks

Several panel unit root tests are already available in the literature, from the early works of Levin and Lin (1992), to the Im, Pesaran and Shin (1997) tests.[6] Although all these proposals aim to test for the unit root hypothesis, they differ in the degree of heterogeneity that is allowed. Thus, the test in Levin, Lin and Chu (2002) –hereafter LLC test– uses the following regression equation:

$$\Delta y_{i,t} = \alpha_{mi} d_{mt} + \delta y_{i,t-1} + \sum_{k=1}^{p} \gamma_k \Delta y_{i,t-k} + \varepsilon_{i,t}, \tag{1}$$

$t = 1, \ldots, T$, $i = 1, \ldots, N$, where d_{mt} denotes the deterministic component. The null hypothesis implies $\delta = 0$ in (1) while the alternative assumes that all the individuals are stationary and that they share the same autoregressive coefficient, *i.e.* $\delta < 0 \; \forall i = 1, \ldots, N$. Moreover, it is assumed that the lag for the autoregressive correction is the same for all the individuals.

In contrast, the tests in Im, Pesaran and Shin (2003) are based on the estimation of (1) where δ has been replaced with δ_i. The null hypothesis is given by

[6] Finally published as Levin, Lin and Chu (2002), and Im, Pesaran and Shin (2003) respectively.

$H_0 : \delta_i = 0 \, \forall i$, whereas the alternative hypothesis is $H_1 : \delta_i < 0 \; i = 1, \ldots, N_1$; $\delta_i = 0 \; i = N_1 + 1, \ldots, N$. Therefore, the null is rejected if there is a subset (N_1) of stationary individuals. As a result, the unit root hypothesis testing can be conducted allowing for a higher degree of heterogeneity provided that under the alternative hypothesis it is not required a common autoregressive parameter. In addition, it accounts for idiosyncratic dynamics since different lag lengths for the parametric correction can be specified for each individual. These authors propose two test statistics. The first test is the standardised group-mean Lagrange Multiplier (*LM*) bar test statistic –the $\Psi_{\overline{LM}}$ test– and the second one is the standardised group-mean *t* bar test statistic –the $\Psi_{\bar{t}}$ test. For instance, the $\Psi_{\overline{LM}}$ test is given by:

$$\Psi_{\overline{LM}} = \frac{\sqrt{N}\left[\overline{LM} - N^{-1}\sum_{i=1}^{N} E\left(LM_i\right)\right]}{\sqrt{N^{-1}\sum_{i=1}^{N} Var\left(LM_i\right)}}, \tag{2}$$

with $\overline{LM} = N^{-1}\sum_{i=1}^{N} LM_i$, where LM_i denotes the individual *LM* test for testing $\delta_i = 0$ in (1), and $E\left(LM_i\right)$ and $Var\left(LM_i\right)$ are obtained by means of Monte Carlo simulation. The $\Psi_{\bar{t}}$ test has a similar expression replacing LM_i by t_i in (2), where t_i denotes the individual pseudo *t*-ratio for testing $\delta_i = 0$ in (1). Under the assumption that the individuals are cross-section independent, it can be shown that both tests converge to the standard Normal distribution once they have been properly standarised.

Finally, we can test the unit root hypothesis computing the test in Maddala and Wu (1999), which instead of combining the individual t_i they suggest pooling the individual p-values. Under the null hypothesis and assuming cross-section independence, the test statistic given by MW$= -2\sum_{i=1}^{N} \ln\left(\pi_i\right) \sim \chi^2_{2N}$, where π_i denotes the p-value of the pseudo *t*-ratio for testing $\delta_i = 0$ in (1). When analysing the performance of these three approaches, Maddala and Wu (1999) concluded that the MW and IPS tests outperform the LLC test. Thus, we are going to test the unit root hypothesis using the IPS and MW tests.

It is possible to complete the stochastic properties analysis that are drawn from the panel data unit root tests through the application of the *LM* test proposed by Hadri (2000), which specifies the null of stationarity allowing for heterogeneous and serially correlated errors. These tests can be considered the panel version of the *KPSS* test applied in the univariate context. Hadri (2000) proposes two models (with and without a deterministic trend) and their decomposition into the sum of a random walk and a stationary disturbance term. He tests the null hypothesis that all the variables (y_{it}) are stationary (around deterministic levels or around deterministic trends), so that for the *N* elements of the panel the variance of the errors is such that:

$$H_0 : \sigma_{u1}^2 = ... = \sigma_{uN}^2 = 0 \tag{3}$$

against the alternative hypothesis that some $\sigma_{ui}^2 > 0$. This alternative allows for heterogeneous σ_{ui}^2 across the cross-sections and includes the homogeneous alternative ($\sigma_{ui}^2 = \sigma_u^2$ for all i) as a special case. It also allows for a subset of cross-sections to be stationary under the alternative. The test statistic is given by:

$$\eta_k = N^{-1} \sum_{i=1}^{N} \left(\hat{\omega}^{-2} T^{-2} \sum_{t=1}^{T} S_{i,t}^2 \right), \tag{4}$$

$k = \{\mu, \tau\}$, where $S_{i,t} = \sum_{j=1}^{t} \hat{\varepsilon}_{i,j}$ denotes the partial sum process obtained from the estimated OLS residuals when regressing the individual time series on a constant –η_μ test– or on a trend –η_τ test. We define $\hat{\omega}^2 = N^{-1} \sum_{i=1}^{N} \hat{\omega}_i^2$, where $\hat{\omega}_i^2$ is a consistent estimate of the long-run variance of $\varepsilon_{i,t}$. Hadri (2000) suggests to estimate the long-run variance in a non-parametric way using the Bartlett kernel. As in McCoskey and Kao (1998) and Hadri (2000), it is not necessary to assume homogeneity of the long-run variance across individuals, so that the expression (4) can include separate estimates for the long-run variance of each individual. After suitable standarisation, the tests are shown to converge to the standard Normal distribution. However and as for the panel data unit root tests presented above, this result is found assuming cross-section independence.

Regarding the deterministic specification, we should bear in mind that the rejection of hysteresis establishes that the unemployment rate evolves in a stationary way around the natural rate. Thus, the deterministic specification when testing both for the unit root hypothesis or for the stationarity hypothesis is the one given by a constant term. Although looking at the pictures of the variables in Figure 1 in the Appendix one could decide to include a time trend in most of them, this specification would mask the fact that the unemployment rate might be experiencing a long transition between shifting natural rates.[7] This is pointed out in Papell et al. (2000) where it is mentioned that while a nonzero trend for unemployment does not make sense asymptotically, a slowly increasing natural rate could be represented by trend stationarity process in small samples.

The results of the panel data unit root and stationarity tests applied to the unemployment rate are reported in Panel A of Tables 1 and 2 in the Appendix, respectively. Assuming that the individuals are cross-section independent, all the tests mainly point to the presence of hysteresis in unemployment for the set of OECD countries that has been analysed. Thus, the unit root hypothesis cannot be rejected by neither the IPS nor the MW tests. Besides, the test in Hadri (2000) strongly rejects the null hypothesis of stationarity. This conclusion is reached irrespectively of the deterministic specification.

The assumption of cross-section independence is rarely found in practice, especially in a globalised economy where the shocks overpass the borders. This is of special interest in our study, due to the inclusion in the panel data set of twelve EU countries, which in part are ruled by common governmental institutions.

[7] This is especially true in the case of France, New Zealand, Spain, Norway and Japan.

These facts question the validity of this assumption. In order to account for cross-section dependence, we have computed the bootstrap distribution of the tests. The details of the bootstrap are given in Maddala and Wu (1999) with 2,000 replications for the bootstrap. Panel B in Tables 1 and 2 reports the percentiles of interest. Except for the η_τ test with the long-run variance computed assuming homogeneity, the previous conclusions remain unchanged. However, note that an homogeneous long-run variance is an unreasonable assumption from the empirical point of view, especially for the unemployment rates of different countries.

In all, the results in this subsection indicate that the hysteresis hypothesis can be present in the unemployment rates, a conclusion that is robust to the presence of cross-section dependence. In general, this conclusion is also in accordance with the previous results in the literature. However, it should be noted that just a mild evidence of stationarity is found when the time trend is used with homogeneous long-run variance. As pointed above, this deterministic specification can be masking the presence of structural breaks that might be shifting the natural rate. This fact is not surprising provided that the natural rate depends on the fundamentals of the economies and these fundamentals change in accordance to the technological progress. Moreover, this contradiction between the unit root and stationarity tests can be thought to be an indicator of the presence of structural breaks –see Cheung and Chinn (1997).

3.2 Panel stationarity tests with structural breaks

The test we apply in this section is an extension of the Hadri (2000) test for stationarity in panel data with the additional feature of allowing for multiple structural changes under the null hypothesis. The specification adopted by the authors allow for heterogeneity in several respects (see Carrion-i-Silvestre et al. (2002)): multiple structural changes, multiple structural changes positioned at different unknown dates, and a different number of breaks for each individual.

They define a stochastic process $y_{i,t}$ such as:

$$y_{i,t} = \alpha_{i,t} + \beta_i t + \varepsilon_{i,t} \tag{5}$$

$$\alpha_{i,t} = \sum_{k=1}^{m_i} \theta_{i,k} D(T_{b,k}^i)_t + \sum_{k=1}^{m_i} \gamma_{i,k} DU_{i,k,t} + \alpha_{i,t-1} + v_{i,t} \tag{6}$$

where $v_{i,t} \sim iid(0, \sigma_{v,i}^2)$ and $\alpha_{i,0}$ is a constant, with $i = \{1, ..., N\}$ individuals and $t = \{1, ..., T\}$ time periods. The dummy variables are defined as: $D(T_{b,k}^i)_t = 1$ for $t = T_{b,k}^i + 1$ and 0 elsewhere, and $DU_{i,k,t} = 1$ for $t > T_{b,k}^i$ and 0 elsewhere (where $T_{b,k}^i$ denotes the k-th date of the break for the *i*-th individual, with $k = \{1, ..., m_i\}$, $m_i \geq 1$). Thus, the data generating process given by (5) and (6) decomposes $\{y_{i,t}\}$ as the sum of a random walk, $\{\alpha_{i,t}\}$, and a stochastic process, $\{\varepsilon_{i,t}\}$, which is a sequence of mixingales. Moreover, $\{\varepsilon_{i,t}\}$ and $\{v_{i,t}\}$ are mutually independent across the two dimensions of the panel. The null hypothesis of stationarity is equivalent to set $\sigma_{v,i}^2 = 0, \forall i = \{1, ..., N\}$, so that the model has the form:

$$y_{i,t} = \alpha_i + \sum_{k=1}^{m_i} \theta_{i,k} DU_{i,k,t} + \beta_i t + \sum_{k=1}^{m_i} \gamma_{i,k} DT_{i,k,t}^* + \varepsilon_{i,t} \tag{7}$$

where $DT_{i,t,k}^* = t - T_{b,k}^i$ for $t > T_{b,k}^i$ and 0 elsewhere. This model includes the following elements:

- Individual effects, that are in fact individual structural break effects (or shifts in the mean caused by the structural breaks).
- Temporal effects if $\beta_i \neq 0$.
- Temporal structural break effects if $\gamma_{i,k} \neq 0$ (when there are shifts in the individual structural time trend).

This specification encompasses Model 1 in Perron and Vogelsang (1992) when $\beta_i = \gamma_{i,k} = 0$ and Model C in Perron (1989), that Carrion-i-Silvestre et al.

(2002) call Model 2, when $\beta_i \neq \gamma_{i,k} \neq 0$. This specification has very convenient characteristics:

- The structural breaks may have different effects on each individual time series (these effects are measured by $\theta_{i,k}$ and $\gamma_{i,k}$).
- These breaks can be located at different dates, because they do not impose the restriction $T^i_{b,k} = T_{b,k}, \forall i = \{1, ..., N\}$.
- The individuals may have different numbers of structural breaks, so that $m_i \neq m_j, \forall i \neq j, \{i, j\} = \{1, ..., T\}$.

The test is formulated as in Hadri (2000), *i.e.*, the average of the individual KPSS statistic. The general expression takes the form:

$$LM(\lambda) = N^{-1} \sum_{i=1}^{N} \left(\hat{\omega}^{-2} T^{-2} \sum_{t=1}^{T} S^2_{i,t} \right) \tag{8}$$

where $S_{i,t} = \sum_{j=1}^{t} \hat{\varepsilon}_{i,j}$ denotes the partial sum process obtained form the OLS residuals of equation (7), and $\hat{\omega}^2 = N^{-1} \sum_{i=1}^{N} \hat{\omega}^2_i$, where $\hat{\omega}^2_i$ is a consistent estimate of the long-run variance of $\varepsilon_{i,t}$. They recommend using either the non-parametric method by Newey and West (1994) or the parametric method by Shin and Snell (2000) to obtain consistent estimates of $\hat{\omega}^2_i$. As before, it is not necessary to assume homogeneity of the long-run variance across individuals, so that the expression (8) can include separate estimates for the long-run variance of each individual. The parameter λ denotes the dependence of the test on the dates of the break. The vector $\lambda_i = (\lambda_{i1}, ..., \lambda_{i,m_i})' = (T^i_{b,1}/T, ..., T^i_{b,m_i}/T)'$ indicates the relative positions of the dates of the breaks on the time period T. Finally, the normalized test statistic converges to a standard Normal distribution and turns out (according to Carrion-i-Silvestre et al. (2002) Monte Carlo results) to be more suited for panels with larger T compared to N.

In order to detect the breaks, Carrion-i-Silvestre et al. (2002) suggest applying the procedure first proposed in Bai and Perron (1998). This consists of specifying a maximum number of breaks ($m^{\max}$), estimating their position for each $m_i \leq m^{\max}, \quad i = \{1, ..., N\}$, testing for the significance of the breaks and, then, obtaining their optimum number and position for each series.

First, to estimate the dates of the breaks, they choose the argument that minimizes the sequence of individual SSR, as in Bai and Perron (1998). Some trimming would be necessary, that is commonly specified as $T_b^i \in [0.15T, 0.85T]$. Once the dates for the possible breaks have been estimated, then the number of optimal structural breaks should be selected for each i (that is, the optimal m_i). Bai and Perron (2001) compare two alternative procedures: information criteria (such as the Bayesian information criterion (BIC) and the modified Schwarz information criterion (LWZ) of Liu, Wu and Zidek (1997)) and the sequential computation of structural breaks, using pseudo F-type test statistics. They recommend using the LWZ criterion when the model includes trending regressors, whereas for non-trending ones the sequential procedure has better performance.

The results of the computation of the $LM(\lambda)$ test allowing for up to $m^{\max} = 5$ breaks, with the deterministic specification given by Model 1, are reported in Table 3. The number of breaks has been selected using the sequential procedure in Bai and Perron (1998). Panel A in Table 3 offers the individual information, *i.e.* the individual KPSS test, number of breaks and their position. In general, at least one structural break was detected by the sequential procedure in all the countries considered and, in six cases, we found up to four breaks. This finding may suggest that the analysis conducted in the previous Section can be wrong, provided that these structural breaks were relevant for the analysis of the stochastic properties of the series.

If we combine the individual information to compute the $LM(\lambda)$ test in Panel B, we realise that the null hypothesis of stationarity is strongly rejected both for the homogeneous and the heterogeneous long-run variance. However, this conclusion is reversed when cross-section dependence is taken into account. Thus, the critical values drawn from the Bootstrap distribution indicate that the null hypothesis cannot be rejected at the 5% level. Therefore, our results point to the absence of hysteresis in the unemployment rate of the OECD countries analysed.

In addition, the last two columns of Panel A show the 10 and 5% critical values computed by simulation of the individual KPSS tests with structural breaks. The null of stationarity cannot be rejected for the countries considered, with the only exception of France and New Zealand at the 5% level. For these two cases, we have repeated the analysis allowing for segmented trends. Although theoretically the unemployment rates should not display a trending behaviour, when transitions between different equilibrium rates are slow, the variables could be more accurately represented by including a deterministic trend –see Papell et al. (2000). The corresponding KPSS statistics are 0.0294 (with a 5% critical value of 0.1004) for France, and 0.0190 (with a 5% critical value of 0.0458) for New Zealand. Thus, stationarity could not be rejected.

There are important differences in our tests results compared with other empirical studies using panel techniques. Song and Wu (1998) do not consider the existence of breaks in their tests, whereas Papell et al. (2000) allow for multiple breaks but do not apply any formal panel data test. Strazicich et al. (2001) apply a *LM* ADF-type panel unit root test allowing for two breaks that does not account for the residual cross-correlation. Although they reject the hysteresis hypothesis for the panel, looking at the individual information that they also present, in only two cases the unit root can be rejected. The restriction in the number of breaks provokes, in our opinion, a misspecification problem of the deterministic component.

In addition, the break dates deserve some more detailed consideration. Due to the relatively long data span we are using in the present paper compared to

Papell et al. (2000), we find four clustering dates for the breaks instead of three. Fourteen occur between 1973-1975, thirteen from 1980 to 1982, ten from 1987-1992 and ten more in 1994-1995. The two first breaks can be easily explained by the consequences on unemployment of the two great oil crises, the third one is associated with the recession of the beginning of the nineties, whereas the recovery of the mid-nineties improved unemployment records in OECD countries, especially in those countries not involved in the Maastricht convergence process.[8]

The inspection of the graphs in the Appendix provides also further evidence on this last issue. In the majority of the cases, the breaks are reflecting an increase in unemployment and, therefore, the associated coefficients are positive. Only in the last part of the sample and, specifically from 1994-1995 on, some countries have considerably reduced unemployment. This is the case of Australia, Canada, Denmark, Ireland, the Netherlands, Norway, New Zealand, the UK and the US, where the new mean, from the mid-nineties, is lower. In contrast, for the majority of the EU countries, the consequences of the recession at the beginning of the nineties have lasted longer due to the efforts to meet the EMU convergence criteria. Although some of these EU countries seem to be reducing unemployment in the last years, these changes cannot be captured by the test.[9]

In all, the results point to the rejection of the hysteresis hypothesis and are compatible with the structuralist theories as described by Phelps (1994) meaning that the majority of shocks to unemployment are temporary but, occasionally, and mainly associated with recessions, shocks can provoke a change in the level of the natural rate of unemployment.

[8] Although Papell et al. (2000) are aware of the importance of allowing for multiple breaks, the time series test they use just allows for one. Using them, they reject hysteresis in 10 out of 16 cases. This problem has been partially addressed in Murray and Papell (2000) where they test for hysteresis in OECD unemployment using a Levin, Lin and Chu (2002) type test, that allows for contemporaneous and serial correlation with just a homogeneous break in the intercept. They reject hysteresis for the European countries considered but not for the rest.

[9] The 15% trimming excludes the first and the last six observations from the sample.

4. Conclusions

In this paper we review the empirical validity of hysteresis in unemployment rates for a group of nineteen OECD countries using annual data for the period 1956-2001. The hysteresis hypothesis can be easily tested in a framework based on unit root or stationarity tests. Therefore, there is an extensive empirical literature on this hypothesis using time series, with mixed and sometimes counterintuitive results. The overwhelming evidence in favour of hysteresis was probably due to lack of power of the tests, pointing to the importance of either expanding the time span (and then allowing for discontinuities in the deterministic components), or increasing the amount of information through panel data. More recently, there is a new generation of empirical papers using tests for unit roots in panels of countries trying to increase the power of the tests thanks to the increase of cross-section information. Up to now, the results are promising but not conclusive.

We contribute to this empirical literature in several respects. First, we apply jointly panel unit root and stationarity tests. Second, we use two versions of each of these tests: the first one, imposing cross-section independence and, the second one, allowing for dependence and computing critical values by boostrap techniques. Third, we apply a new panel stationarity test incorporating multiple structural changes endogenously determined, and also accounting for cross-correlation in the residuals. These two features provide important power gains compared to the time series equivalent tests.

To summarize the results, the rejection of hysteresis in unemployment depends critically on the above mentioned characteristics of the tests. First, using panel unit root tests we cannot reject hysteresis in unemployment, even when allowing for cross-section dependence. Second, there is mild evidence in favour of the natural rate hypothesis with panel stationarity tests, homogeneous long-run variance and cross-section dependence. Finally, the results change dramatically when we also allow for structural breaks in the stationarity tests: hysteresis in unemployment is not only strongly rejected in the panel, but also in the individual country tests. Moreover, the dates of the breaks are consistent with the results in previous literature and support the structuralist view of unemployment meaning that temporary shocks have highly persistent but not permanent effects on unemployment. At the same time, structural factors can affect the natural unemployment rate and, therefore, unemployment would be stationary around a process that is subject to structural breaks.

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Appendix A. Tables and graphs

Table 1: IPS and Maddala and Wu (MW) panel unit root tests

Panel A: Assuming cross-section independence

	Constant		Time trend	
	Test	p-val	Test	p-val
$\Psi_{\bar{t}}$	0.826	0.796	0.044	0.518
$\Psi_{\overline{LM}}$	-1.448	0.926	-0.213	0.585
MW	22.829	0.975	30.018	0.819

Panel B: Bootstrap distribution (allowing for cross-section dependence)

Constant

	1%	2.5%	5%	10%	90%	95%	97.5%	99%
$\Psi_{\bar{t}}$	-4.035	-3.397	-2.860	-2.264	2.481	3.479	4.452	5.737
$\Psi_{\overline{LM}}$	-2.991	-2.464	-2.024	-1.464	2.744	3.483	4.092	4.893
MW	9.645	13.406	16.921	22.096	63.065	69.929	77.858	85.841

Time trend

	1%	2.5%	5%	10%	90%	95%	97.5%	99%
$\Psi_{\bar{t}}$	-4.708	-4.108	-3.636	-3.065	1.539	2.405	3.276	4.285
$\Psi_{\overline{LM}}$	-3.014	-2.296	-1.719	-1.090	3.272	3.879	4.399	5.064
MW	18.256	22.952	27.221	32.504	78.465	86.399	94.495	102.581

Table 2: Panel stationarity KPSS test

Panel A: Assuming cross-section independence

	Constant		Time trend	
	Test	p-val	Test	p-val
Homogeneous	9.307	0.000	4.351	0.000
Heterogeneous	8.363	0.000	4.751	0.000

Panel B: Bootstrap distribution (allowing for cross-section dependence)

	1%	2.5%	5%	10%	90%	95%	97.5%	99%
Constant								
Homogeneous	-3.449	-3.246	-3.063	-2.741	4.487	6.742	9.226	13.819
Heterogeneous	-3.174	-3.008	-2.740	-2.474	3.898	5.898	8.450	11.999
Time trend								
	1%	2.5%	5%	10%	90%	95%	97.5%	99%
Homogeneous	-2.918	-2.499	-2.214	-1.786	4.075	5.341	6.749	8.582
Heterogeneous	-2.593	-2.186	-1.892	-1.533	3.245	4.530	5.770	7.247

Table 3: Panel KPSS tests and individual test. Sample 1956-2001 (T=46)

Panel A: Individual information

	Individual tests	m_i	$T^i_{b,1}$	$T^i_{b,2}$	$T^i_{b,3}$	$T^i_{b,4}$	10%	5%
Australia	0.048	4	1974	1981	1989	1995	0.081	0.101
Austria	0.068	2	1961	1981			0.123	0.147
Belgium	0.073	4	1974	1980	1986	1992	0.083	0.104
Canada	0.053	3	1974	1981	1995		0.094	0.114
Denmark	0.062	3	1961	1974	1995		0.102	0.125
Finland	0.106	2	1975	1991			0.107	0.128
France*	0.129	3	1974	1980	1991		0.087	0.106
Germany	0.049	4	1961	1974	1981	1992	0.061	0.071
Ireland	0.081	3	1974	1982	1995		0.091	0.110
Italy	0.076	3	1961	1974	1982		0.091	0.110
Japan	0.074	3	1974	1981	1995		0.094	0.114
Netherlands	0.070	4	1973	1980	1988	1995	0.076	0.094
Norway	0.049	4	1971	1981	1988	1995	0.068	0.082
New Zealand*	0.191	3	1980	1988	1994		0.124	0.159
Spain	0.122	2	1974	1980			0.123	0.149
Sweden	0.132	1	1991				0.227	0.297
Switzerland	0.072	3	1961	1982	1991		0.099	0.123
United Kingdom	0.089	4	1974	1980	1987	1995	0.081	0.102
USA	0.048	3	1974	1986	1995		0.089	0.108

Panel B: Panel Stationarity tests

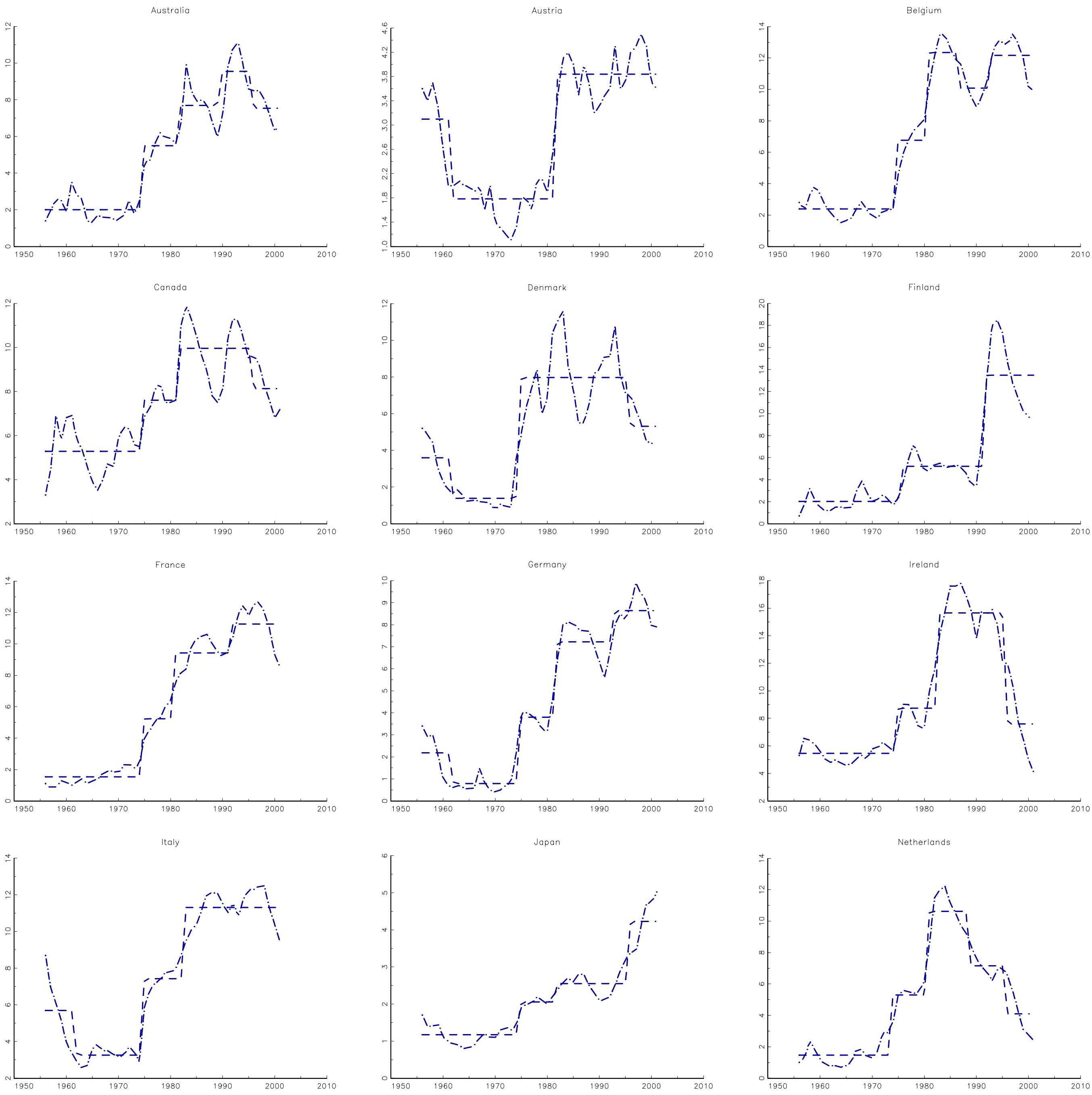
	Test	p-val
Homogeneous	5.126	0.000
Heterogeneous	4.883	0.000

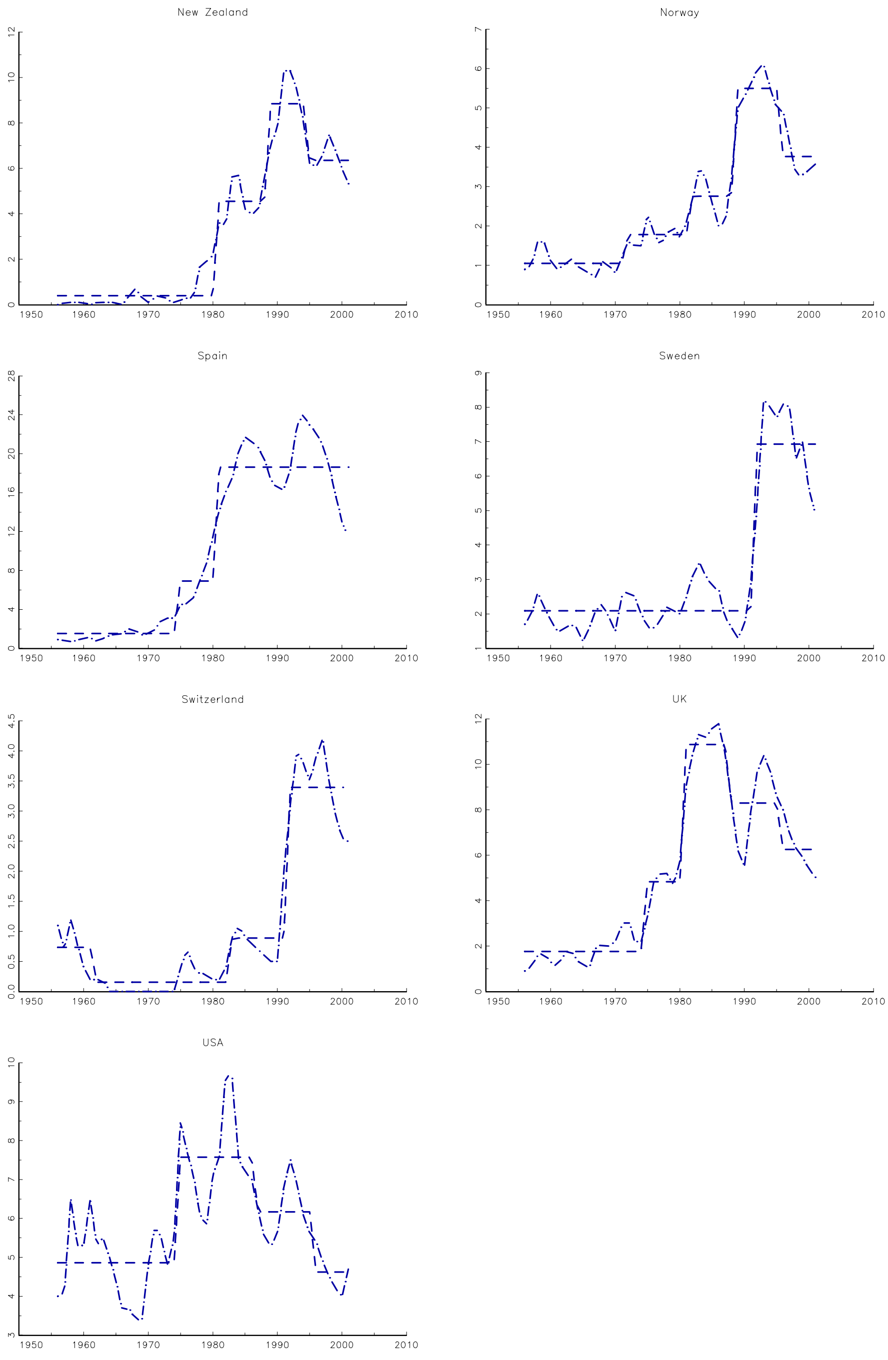
Bootstrap distribution (allowing for cross-section dependence)

	1%	2.5%	5%	10%	90%	95%	97.5%	99%
Homogeneous	0.538	0.863	1.145	1.486	4.493	5.181	5.639	6.346
Heterogeneous	1.113	1.358	1.62	1.895	4.407	4.914	5.324	5.729

The * denotes that for France and New Zealand the null hypothesis of stationarity around a broken trend cannot be rejected at the 5% level of significance.

Figure 1. Unemployment rates and estimated broken trends

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