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**NEW REVELATIONS ABOUT UNEMPLOYMENT PERSISTENCE IN SPAIN.  
Time series and panel data approaches using regional data.**

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5 **NEW REVELATIONS ABOUT UNEMPLOYMENT PERSISTENCE IN SPAIN.**  
6 **(Time series and panel data approaches using regional data)**  
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20  
21  
22 **ABSTRACT**  
23

24 This paper aims to re-examine the persistence of unemployment in Spain. For this  
25 purpose, we use time series and cross-section analysis. From a time series viewpoint we  
26 disaggregate unemployment by regions, and use unit root tests, AR coefficients and  
27 fractional differencing parameters as indicators of persistence. For the cross-section  
28 approach, we first estimate mean regressions of regional unemployment rates. Then,  
29 using a panel of 114 periods and 50 provinces, we estimate pooled, fixed and random  
30 effects models. Finally, following some recent developments, we implement several  
31 panel data unit root tests. Previous studies had already shown the strong persistence of  
32 Spanish unemployment. Our disaggregated analysis extends that finding to reveal that  
33 the persistence is greater in the most industrialised regions. The results also suggest that  
34 a structural break took place in 1994, implying a decline in the unemployment  
35 persistence since then.  
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41 **JEL Classification:** J64

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## 1. Introduction

The high persistence of unemployment in the developed countries since the first oil shock has produced an intense debate about the different theories explaining unemployment behaviour. On the one hand, some traditional theories (Friedman, 1968, Phelps, 1967, 1968) assume that fluctuations in unemployment are stationary around a natural rate. Occasionally, these fluctuations may be permanently changing the natural rate of unemployment from one level to another. On the other hand, the hysteresis hypothesis (Blanchard and Summers, 1986, 1987) assumes that shocks in unemployment have a permanent effect on the level of the variable, implying that unemployment is nonstationary.

The concept of persistence might be considered somehow a conciliating theory. Persistence implies mean reversion, even if the speed of adjustment towards the equilibrium level is slow, thereby being a special case of the natural rate hypothesis. At the same time, the hysteresis theory is also closely related to the concept of persistence, insofar as it takes long time for the shocks to disappear completely. In this context, the unemployment series is modelled by autoregressions (with the roots close to the unit circle) or by some other techniques like fractional integration.

The sources of European unemployment persistence have been examined in a number of papers. Some of them highlight the presence of persistence mechanisms that lead the current equilibrium unemployment rate (UR) to be positively related to previous realizations of unemployment (Cf. Bean, 1997; or Jimeno and Bentolila 1998 for the case of Spain). The goal of this paper is not to explain those mechanisms, but simply to examine the degree of aggregate and regional UR persistence in Spain, for the period 1976-2004.

Previous studies have examined the unemployment persistence from an aggregate approach, using time series techniques. The degree of persistence has been usually measured through the estimated coefficients of AR(I)MA models. (Blanchard and

1  
2  
3 Summers, 1986, and Barro, 1988). More recently, new developments in econometrics have  
4  
5 studied unemployment persistence through fractionally integrated (ARFIMA) models. (See,  
6  
7 i.e., Tschernig and Zimmermann, 1992; Crato and Rothman, 1996; Caporale and Gil-Alana,  
8  
9 2002; and Gil-Alana, 2001a, 2002).

10  
11  
12 The study of unemployment persistence also requires accounting for regional  
13  
14 disparities. As stated by Blanchard et al (1995), the most striking fact in Spanish regional  
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16 trends is not just the difference in unemployment rates across regions, but rather the  
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18 persistence of these differences. In fact, regional considerations might help us to understand  
19  
20 more deeply the nature of unemployment persistence.  
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23  
24 The interest for revisiting the Spanish case is unquestionable given its high UR.  
25  
26 More importantly, Spain is an obvious laboratory where to apply our regional approach,  
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28 since regional discrepancies of rates between provinces are enormous. In the last quarter of  
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30 2004 various southern provinces (like Badajoz, Córdoba, Jaén and Cádiz) had UR above  
31  
32 20%, whereas others (Navarra, Lleida, Rioja, Soria and Teruel) presented rates of less than  
33  
34 5%, far below the average UR in Europe (which in 2004 was 9.2% for the EU-25 zone).  
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39 In summary, this paper aims not just to analyse thoroughly the Spanish experience,  
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41 but to do it in a comprehensive way by adopting different perspectives and using a broad  
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43 array of empirical devices. Should the same result be achieved from diverse approaches, the  
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45 conclusion could be stated in a very consistent way. Hence, this study is challenging as far  
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47 as it can be used to validate the accuracy of some recent empirical methods that we have  
48  
49 employed. The outline of the paper is as follows: Sections 2 and 3 address the concept of  
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51 persistence in time series and cross-section / panel data models respectively. Section 4  
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53 describes the data and presents the empirical results, while Section 5 concludes.  
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## 2. Time series persistence

From a time series viewpoint a classic model of persistence is the unit root case, where the effect of the shocks persists forever. To illustrate this point, consider the simplest case: the random walk model,

$$(1 - L)u_t = v_t, \quad t = 1, 2, \dots, \quad (1)$$

where  $u_t$  is the UR series we observe;  $L$  is the lag-operator ( $Lu_t = u_{t-1}$ ) and  $v_t$  is i.i.d.

Note that after recursive substitutions, (1) can be re-written as:

$$u_t = \sum_{j=1}^t v_j, \quad t = 1, 2, \dots, \quad (2)$$

and thus, a 1-unit shock has a 1-unit effect on the future path of the series.

Let us suppose now that  $v_t$  in (1) is an ARMA( $p, q$ ) process of form:

$$\phi_p(L)v_t = \theta_q(L)\varepsilon_t, \quad t = 1, 2, \dots, \quad (3)$$

with all the roots of  $\phi_p(L)$  within the unit circle and all the roots of  $\theta_q(L)$  within or in the unit circle. In such a case,  $v_t$  can also be expressed in terms of a  $MA(\infty)$  representation,

$$v_t = \sum_{j=0}^{\infty} b_j \varepsilon_{t-j}, \quad t = 1, 2, \dots, \quad (4)$$

and the coefficients  $b_j$  will slowly (in fact, exponentially) decay to zero. These coefficients are usually associated with the short run dynamics of the series. In light of this, it is crucial to correctly determine the order of integration of the series. Thus, if it is 1 (i.e, a unit root with or without ARMA components) the series is said to be persistent as opposed to the case of simple stationary ARMA structures, where the effect of shocks disappears in the future. In the latter case the series is said to be  $I(0)$  since the order of integration is 0. Note that here persistence is measured by the impulse responses in (4) (the  $b_j$ -coefficients). Thus, i.e., if  $u_t$  is a stationary AR(1) process:

$$u_t = \phi u_{t-1} + \varepsilon_t, \quad t = 1, 2, \dots, \quad (5)$$

the model can also be expressed as

$$u_t = \sum_{j=0}^{\infty} \phi^j \varepsilon_{t-j}, \quad t = 1, 2, \dots, \quad (6)$$

and the higher is the AR coefficient  $\phi$ , the higher is the persistent behaviour of the series, though disappearing in the long run as long as  $|\phi| < 1$ .

Among the many procedures for testing unit roots, the tests of Dickey and Fuller (ADF, 1979) are the most widely used. These tests involve the regression of the first-difference of the series on its lagged level and  $k$  lagged first differences. To select the value of  $k$ , the Ng and Perron (2001) procedure is applied. The starting upper bound,  $k_{\max}$ , is then determined by applying the Schwert (1989) criterion. In addition to ADF tests, we can also employ a DF-GLS test, which is a modified Dickey-Fuller test in which the series has been transformed by GLS regressions. For the latter tests, we can use the interpolated critical values proposed by Elliot, Rothenberg and Stock (1996).

In view of the previous discussion the classic approach to the time series persistence consists of determining if the series is nonstationary  $I(1)$  or stationary  $I(0)$ , and, in the latter case, examining the coefficients that are associated with the short run dynamics. However, in the last twenty years a new model has emerged that avoids the strong dichotomy produced by the  $I(0)$  and  $I(1)$  specifications. This is because the number of differences required to get  $I(0)$  stationarity may not necessarily be an integer value (usually 1) but is possibly a real value.

We define a  $I(d)$  process  $\{v_t, t = 0, \pm 1, \dots\}$  as a covariance stationary process with spectral density that is bounded and bounded away from zero at the zero frequency. In such a case,  $u_t$  is  $I(d)$  if:

$$(1 - L)^d u_t = v_t, \quad t = 1, 2, \dots, \quad (7)$$

where  $d$  can be any real value. Note that using the Binomial expansion:

$$(1 - L)^d = \sum_{j=0}^{\infty} \binom{d}{j} (-1)^j L^j = 1 - dL + \frac{d(d-1)}{2} L^2 - \dots$$

(7) can be expressed as

$$u_t = \sum_{j=1}^{\infty} a_j y_{t-j} + v_t, \quad t = 1, 2, \dots,$$

and similarly, (if  $d > -0.5$ ), using the expansion of  $(1-L)^{-d}$ ,  $u_t$  admits a  $MA(\infty)$  representation:

$$u_t = \sum_{j=0}^{\infty} c_j v_{t-j}, \quad t = 1, 2, \dots,$$

with  $c_0 = 1$ , and  $c_j$  decaying to zero at a hyperbolic “slow” rate (if  $d < 1$ ). Therefore the parameter  $d$  also plays a crucial role in describing the time series persistence: the higher the  $d$  is, the greater is the persistent behaviour of the series. Similar to the unit root case ( $d = 1$ ),  $v_t$  in (7) can be extended to allow for short run dynamics, decaying exponentially to zero.

Attempting to summarize some of the literature on hysteresis and persistence on unemployment, Gordon (1989) defined full hysteresis as the case of a unit root and persistence as stationarity AR. In that study, he concludes that no evidence of full hysteresis was found in five countries (France, Germany, USA, Japan and the UK) for the time period 1873-1986. Graafland (1991) stated that, in the 80s, the labour market in the Netherlands was characterized by high and persistent level of unemployment. Lopez et al. (1996) reported that monthly unemployment in Spain (1976m6-1994m10) was consistent with hysteresis. On the other hand, Nott (1996) did not find evidence of hysteresis in Canada, while Wilkinson (1997) did. Mitchell (1993) examines hysteresis for the OECD countries, and Leon-Ledesma (2000) analyses the case of the US states and the EU countries. Other studies on unemployment hysteresis are Song and Wu (1997), Roed et al. (1999) and Roed (1999), who proposes an alternative way of modelling unemployment hysteresis in which permanency is viewed as a continuous phenomenon.



### 3. Cross-section and Panel data persistence

Cross-sectional techniques may help to examine if regional UR are persistent or not. In the context of regional convergence, unemployment persistence could be evaluated by computing mean regressions of regional UR. In the regressions, the dependent variable is obtained after taking differences of the UR, where the length of the spell for which the differences are taken changes. This procedure was employed by Blanchard and Katz (1992) and Bertola and Ichino (1995). The estimated models are of the form:

$$\Delta u^i = \alpha + \beta u^i_q + \varepsilon \quad (8)$$

where  $u^i_q$  is the UR in region  $i$  at the starting period  $q$ , and  $\Delta u^i$  is the change in the UR in that region over the following  $t$  periods. If the cross-sectional coefficient of the initial UR ( $\beta$ ) becomes more negative when the length of the spell increases, it means that regional UR are not persistent (since their reversion towards the aggregate mean is stronger over longer intervals).

Regarding panel data methods, some developments can also be implemented so that we may benefit from the better statistical properties associated with large samples. Panel data analysis permits us extracting greater information from the data and, more importantly, taking into account the possible influence of individual heterogeneity components. In particular, by isolating the unobservable individual heterogeneity, the fixed and random effects models filter the impact that these unobservable elements have upon the dependent variable.

Given the temporal dimension of the data and the nature of unemployment persistence itself, it seems imperative to specify and estimate the dynamic structure of the model. Accordingly, we also implement the technique proposed by Arellano and Bond

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2  
3 (1991), which is advised to deal with dynamic panel data.<sup>1</sup> The GMM estimators use  
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5 variables in differences to eliminate unobservable individual effects, and include lagged  
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7 values (in levels) as instruments to correct for simultaneity.  
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10 Finally, we also consider unit root tests for panel data, following the lines of  
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12 Levin, Lin and Chu (LLC, 2002) and Im, Pesaran and Shin (IPS, 2003). The former  
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14 method provides an alternative approach to weigh up the results obtained when  
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16 computing ADF tests for time series data. LLC approach is appropriated for panels of  
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18 moderate size (say, 10 to 250 individuals, with 25-250 time series observations) and is  
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20 particularly useful wherever the (time) dimension of the panel is not large enough, so  
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22 that unit root test procedures performed separately to each individual in the panel would  
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24 not be sufficiently powerful. The IPS (2003) test is prescribed for panels where a higher  
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26 degree of heterogeneity exists in the cross-section dynamics. Unlike LLC (2002), which  
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28 assumed that all series are stationary under the alternative, IPS (2003) is consistent  
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30 under the alternative that only a fraction of the series is stationary.  
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#### 4. Data and results

41 Data on unemployment were obtained from the EPA (Encuesta de Población Activa.  
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43 INE, Spain). The sample consists of quarterly (seasonally unadjusted) data for the time  
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45 period 1976q3 – 2004q4. Although there were some methodological changes over this  
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47 period, the data series provided by the INE has been conveniently homogenized  
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49 according to the methodological guidelines given by EPA-2002.<sup>2</sup> The time series  
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55 <sup>1</sup> Arellano and Bond (1991) derived a Generalized Method of Moments (GMM) estimator using lagged  
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57 levels of the dependent variable and the predetermined variables and differences of the strictly exogenous  
58  
59 variables. This methodology assumes that there is no autocorrelation in the error term.

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<sup>2</sup> The ongoing nature of the EPA has allowed the INE, since the 3<sup>rd</sup> quarter of 1976, to compute  
homogeneous data on the main characteristics of the labour market. In order to ensure such homogeneity  
in the results, it was required to carry out retrospective adaptations (from 1994 until the 2<sup>nd</sup> quarter of  
1987) as well as to incorporate to the survey some improvements applied since 1999. For a detailed  
description of changes affecting EPA-2002, see: <http://www.ine.es/daco/daco42/daco4211/notamet.htm>.

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3 analysis uses aggregate UR for the whole country, as well as separate UR for each  
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5 region.<sup>3</sup> Panel data analysis is carried out using a set of 5,700 observations for 114  
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7 quarterly periods and 50 provinces.  
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10 To measure unemployment persistence at the regional level, the analysis can be  
11  
12 based on absolute regional UR or, alternatively, on regional relative UR. (The latter uses  
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14 differentials; that is, the regional UR minus the national UR rate). Given our interest for  
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16 examining unemployment persistence in Spain as a whole, we have chosen the first  
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18 route. Other results based on the two approaches can be found in Jimeno and Bentolila  
19  
20 (1998).  
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#### 25 **4.1 Results based on time series approaches**

26 According to the classic (time series) perspective we first determine if the  
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28 unemployment series is stationary or not. A visual inspection at the series, displayed in  
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30 Figure 1, does not produce clear conclusions. The first 50 sample autocorrelation values  
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32 are also displayed in Figure 1, and they show a very slow decay to zero. Moreover, the  
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34 periodogram presents the highest value at the lowest frequency. This may be an  
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36 indication that first differences are required, implying thus nonstationarity I(1).  
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38 Nevertheless, these features might also be the result of a stationary AR process with the  
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40 roots close to the unit circle.  
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46 **[Insert Figure 1 about here]**  
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49 Several methods have been proposed for testing the hypothesis of a unit root. Table  
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51 1 displays the results of the ADF and DF-GLS tests for the whole country as well as for  
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53 each of the 17 regions. The latter were computed using Elliott-Rothenberg-Stock (1996)  
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55 efficient test for an autoregressive unit root, which has a better overall statistical  
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60 <sup>3</sup> Spain is divided into 50 provinces, which are gathered in 17 regions, with different cultural traditions and political autonomy: Andalucía, Aragón, Asturias, Baleares, Canarias, Cantabria, Castilla-Mancha, Castilla-León, Cataluña, Valencia, Extremadura, Galicia, Madrid, Murcia, Navarra, País Vasco and Rioja.

performance. The procedures were carried out for the model with and without trend, and they include as many lagged first differences as indicated by  $k$  in columns (1) and (4). The tests provide no evidence against the unit root hypothesis: the unit root null cannot be rejected for any of the 17 regions at the 1%, and not even at the 5% significance level.

**[Insert Table 1 about here]**

However, the method presented above has very low power if the alternative is an AR process with the roots close to the unit circle (Campbell and Perron, 1991; DeJong et al., 1992), but also if they are of a fractional form (Diebold and Rudebusch, 1991; Hassler and Wolters, 1994; Lee and Schmidt, 1996).<sup>4</sup> Hence, we also use as a measure of persistence the fractional differencing parameter  $d$ , as described in Section 2.

The first two values in the first row in Table 2 display the estimates of the AR parameter assuming that  $d = 0$  and that  $y_t$  follows a non-seasonal and a seasonal AR(1) process.<sup>5</sup> We observe that in both cases the coefficients are very close to 1: it is 0.9944 in the non-seasonal case, and 0.9518 with a seasonal AR(1) process. In the right hand side of the table we display the estimates of  $d$  based on a parametric approach of Robinson (1994). (See Appendix A for a full description of this procedure). The latter method uses a Whittle function, which is an approximation to the likelihood function. Since it is parametric, we have to specify the functional form of the  $I(0)$  disturbances  $u_t$  in (7). We try with white noise, Bloomfield and seasonal AR(1)  $v_t$ . The model of Bloomfield (1973) is a non-parametric way of modelling  $v_t$  that produces autocorrelations decaying exponentially as in the AR case (See, e.g., Gil-Alana, 2001b). We observe that for the three cases the values of  $d$  are much higher than 1, ranging

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<sup>4</sup> See also Cook (2002) for spurious rejections using Dickey-Fuller tests.

<sup>5</sup> A seasonal AR(1) process can be defined as  $(1 - \phi L^s)u_t = \varepsilon_t$ , where  $s$  is the number of time periods within a year.

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3 between 1.318 and 1.381. Moreover, the unit root hypothesis ( $d = 1$ ) is rejected in the  
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5 three cases in favour of higher orders of integration.  
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8 **[Insert Table 2 and Figure 2 about here]**  
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10 Figure 2 displays the estimates of  $d$  based on a semiparametric approach (Robinson,  
11 1995; See Appendix B) along with the 95% confidence interval corresponding to the  $I(1)$   
12 hypothesis. It is semiparametric in the sense that we do not specify any functional form for  
13 the  $I(0)$  disturbances  $v_t$ . We see that practically all values are above the  $I(1)$  interval,  
14 implying orders of integration higher than 1, which is consistent with the results based on  
15 the parametric approach.  
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24 Next, we wonder if the unemployment persistence in Spain has experienced any  
25 substantial alteration along the last three decades. In other words, we are concerned with  
26 the possibility of a structural break in the data, since a number of institutional changes  
27 have taken place during this period. Various techniques can be applied in order to test  
28 structural shifts in regional UR (see, e.g., Baddeley, 1998, who studies the impact of the  
29 1980s recession on regional unemployment in Britain). We employ here a methodology  
30 suggested by Hsu and Kuan (2004), testing simultaneously the order of integration ( $d$ )  
31 and the time of the break, which, in this context, is a single mean shift. (Appendix C).  
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43 **[Insert Figure 3 about here]**  
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45 The upper part of Figure 3 displays the estimates of the time break across the  
46 bandwidth number  $m$ . We see that in all except two cases, the break takes place at the fourth  
47 quarter in 1993. The lower part of the figure refers to the order of integration of the series  
48 and the results are to some extent ambiguous. If the bandwidth number  $m$  is smaller than  
49  $T/4$ , the order of integration is strictly higher than 1, however, if  $m > T/4$ , the values are  
50 within the  $I(1)$  interval. Thus, it seems that once the break is taken into account the evidence  
51 of orders of integration higher than 1 is not as clear as before. In any case, from the analysis  
52 of the results presented so far it seems that unemployment, at an aggregate level, is  
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3 nonstationary, with an order of integration equal to or larger than 1, supporting thus the  
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5 hysteresis hypothesis in the unemployment series for Spain.  
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9 Next, we examine the persistence of UR at a regional level. Starting with the AR  
10 coefficients, we see (Table 2) that all values are very close to 1. The lowest values are  
11 those referring to Baleares, with the coefficients smaller than 0.90 in the two cases. At  
12 the other end, Cataluña and País Vasco are two of the areas with the highest coefficients.  
13 Performing the parametric procedure of Robinson (1994) (in the right hand side of the  
14 table) the most noticeable features are first the fact that for Baleares, the unit root null  
15 hypothesis is rejected in favour of smaller orders of integration. This may be related to  
16 the tourism sector, which is highly predominant in this region. On the opposite side we  
17 find that Cataluña, País Vasco and Madrid, precisely among the most industrialized  
18 areas of Spain, are the regions where  $d$  is found to be higher than 1.<sup>6</sup>  
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32 **[Insert Figure 4 about here]**  
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34 Figure 4 displays the estimates of  $d$  based on the Whittle semiparametric  
35 approach of Robinson (1995). The results here can be grouped into three different  
36 categories: Baleares, with values smaller than one in most of the cases; Cataluña, País  
37 Vasco, Madrid, Aragón and Valencia, with values of  $d$  strictly above 1 in many cases;  
38 and the remaining regions, with values of  $d$  within the unit root interval in most of the  
39 cases. Thus, the results based on the semiparametric approach are completely in line  
40 with the parametric method: Baleares presents the smallest degree of UR persistence,  
41 while the most industrialized areas are those with the highest degree of persistence.  
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52 **[Insert Table 3 about here]**  
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58 <sup>6</sup> Though not reported in the paper we also examined the orders of integration of unemployment  
59 disaggregating the series by sectors. It was found that the lowest degree of integration was obtained for  
60 the Services sector. On the other extreme, Industry had the highest levels of persistence. Tolvi (2003)  
found that unemployment in Finland is less persistent for females and young people. We leave for future  
research the analysis of persistence for groups of age and sex in Spain.

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3 In view of the potential presence of a break taking place at 1993q4, we compute  
4 again, in Table 3, the parametric approaches but using now data ending at 1993q4. We  
5 see here that values of  $d$  higher than 1 are once more obtained for Cataluña, Valencia,  
6 Aragon, Madrid and País Vasco. However, for the aggregate as well as for most of the  
7 regions, the order of integration is higher in this period compared with the whole  
8 sample, meaning that persistence might have been reduced since 1993q4 onwards.  
9

10 We can summarize the previous results by saying that unemployment in Spain is  
11 highly persistent, a result that is inferred from the ADF and DF-GLS tests. More  
12 significantly, when using autoregressions, the coefficients are very close to 1, while  
13 when adopting fractionally integrated approaches, the values of  $d$  are higher than 1 in all  
14 cases. Besides, if a break is taken into account, it seems to take place at 1993q4, and the  
15 level of persistence declines from that period onwards. From a regional perspective,  
16 Balears presents the lowest degree of persistence, due possibly to the influence of the  
17 tourism sector, predominant in this region. On the contrary, some of the most  
18 industrialized areas (Cataluña, Madrid and País Vasco) are those with the highest levels  
19 of persistence.  
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21 Our results are so far consistent with other previous studies on unemployment in  
22 Spain (e.g. Jimeno and Bentolilla, 1998), finding evidence of high levels of persistence  
23 at both aggregate and regional level. One explanation to this evidence might be the low  
24 geographical labour mobility observed in Spain during the considered period (e.g.  
25 Garcia-Rubiales, 2005). This idea is congruent with the results for Balears, which is  
26 presumably the region with the highest labour mobility and the lowest UR persistence.  
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#### 4.2 Results based on cross-section and panel data approaches

41 The analysis made so far is based exclusively on time series approaches. Yet, the nature  
42 of unemployment persistence can be better understood exploiting the information  
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3 contained in a panel data set. Applying the empirical methods that were described in  
4  
5 Section 3, we examine, from different perspectives, the persistence of Spanish UR. The  
6  
7 sample includes quarterly data for 114 periods and 50 provinces.  
8  
9

10  
11 Once the temporal dimension comes into the scene, we need to pay attention to the  
12  
13 periods in which institutional features have taken place in Spain. For this reason, and for the  
14  
15 sake of simplicity, we have arranged the cross-sectional analysis considering homogeneous  
16  
17 periods of 6 years each (starting at 1976 and attending specially to 1982, 1988, 1994 and  
18  
19 2000). Note that Spain joined the European Union (EU) in 1986 and the European  
20  
21 Monetary System (EMS) in 1989. After some initial transitional years, the Socialist Party  
22  
23 (PSOE) formed the government from 1982 until 1996. Since then, and almost until the end  
24  
25 of the sample period, the conservative (right-wing) Popular Party (PP) has been driving the  
26  
27 country.<sup>7</sup>  
28  
29  
30

31  
32 Following the lines of previous studies (Jimeno and Bentolila, 1998; Wu, 2003;  
33  
34 etc.), we offer an initial flavour of Spanish unemployment persistence in Figure 5. This  
35  
36 scatter graph represents provincial UR (annual averages from quarterly data), for different  
37  
38 years, against the corresponding records for the year 1976. The positive slope in all the  
39  
40 graphs of Figure 5 means that the ranking of provinces according to their UR has remained  
41  
42 noticeable stable over the years. This fact suggests a high degree of persistence of regional  
43  
44 unemployment differentials, which is noticeable broader than expected within an integrated  
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46 economy.  
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49

50  
51 **[Insert Figure 5 and Table 4 about here]**  
52

53  
54 To get a more accurate perception of this issue, Table 4 gathers the estimated  
55  
56 coefficients for several regressions between provincial UR for two different years. In all  
57  
58 cases, the significance of the estimated coefficients is remarkably strong as well as the  
59  
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<sup>7</sup> Some major economic and political events in Spain are summarized by Bentolila and Blanchard (1990), p.238. The reforms of the Spanish labour market are described in European Commission (2005), p.49.



1  
2  
3 explanatory power of the regressions. The results in the first row in Table 4 seem to indicate  
4 increasing divergence of unemployment persistence in Spain until 1994. From that year  
5 onwards the trend of regional UR persistence has been reverted, inasmuch as the estimated  
6 coefficients (the slopes) experience a decline after that year. From inspection of the whole  
7 table, we can conclude that regional UR persistence in Spain increased between 1982 and  
8 1988, remained high and stable between 1988 and 1994, and declined consistently since  
9 1994. Note that the decline experienced since 1994 is congruent with the above results.

10  
11  
12 In addition, we also compute mean regressions of regional UR. The results vary  
13 depending both on the length of the spell for which the differences were taken (indicated in  
14 rows) and on the starting period (in columns). The results in Table 5 report the point  
15 estimates and t-statistics of  $\beta$  from cross-sectional regressions starting at different time  
16 periods. The estimations were computed for the annual averages obtained from quarterly  
17 data. The constant is not shown and absorbs the effects of aggregate UR changes.

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34 **[Insert Table 5 about here]**

35  
36 The results manifest an interesting contrast. If we take 1976 as the starting year, the  
37 values are positive and statistically significant up to the point in which we have a spell of  
38 length 24 years. (In fact, we have to wait 28 years to find a negative sign). It means that  
39 extremely high persistence exists, since reversion towards the aggregate mean takes long  
40 time to occur. The analysis of column (2) suggests that strong persistence still exists, at  
41 least, until 1996, whereas the negative signs right from the first row of columns (3), (4) and  
42 (5) indicates a change of behaviour in the unemployment persistence. It is certainly the case  
43 for the starting year 1994, in which reversion towards the aggregate mean is much faster  
44 than in previous periods. When considering the starting years 1988 and 1994, we realise  
45 that the negative coefficients become significant after 10 and 4 years respectively,  
46 suggesting that regional unemployment persistence is lower since 1998 onwards. This result

1  
2  
3 is consistent with the mentioned structural break and could be explained by the labour  
4  
5 market reforms introduced in Spain in the years 1994 and 1997.<sup>8</sup>  
6  
7

8 In summary, the previous results allow us to conclude that the dispersion of regional  
9  
10 UR has persistently increased in Spain during the 80s, but it has experienced a reverted  
11  
12 trend at the mid of the 90s. It has declined perhaps since 1994, and undeniably since 1998.  
13  
14

15 Up to now, we have studied unemployment persistence either adopting time series  
16  
17 or cross-sectional methodologies. Next, we focus on panel data results. Table 6 collects the  
18  
19 OLS and GLS estimates for the pooled model. Given that the estimations may have  
20  
21 problems of heteroskedasticity, the former estimates were computed for robust standard  
22  
23 errors, while the GLS estimations were performed specifying a heteroskedastic error  
24  
25 structure.  
26

27 **[Insert Table 6 about here]**  
28

29 The results in Table 6, columns (3) and (6), include 17 dummies corresponding to  
30  
31 the regions. The magnitude of the AR(1) coefficient, close to one in all the models,  
32  
33 corroborates the strong persistence of Spanish unemployment, which is slightly lessen  
34  
35 whenever regional dummies are present. More interestingly, the temporal dummies, that  
36  
37 were included to explore breaks in unemployment behaviour, suggest a positive variation in  
38  
39 1982, whereas they manifest a significant decrease in 1994 and 2000. Note that this is again  
40  
41 consistent with a break taking place in the last quarter of 1993, as time series analysis  
42  
43 pointed out. It is also consistent with the conclusions reached from the cross-sectional  
44  
45 results of Table 5.  
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49 In any case, the information contained in the data has not yet been fully exploited,  
50  
51 and could be enhanced by applying the fixed and random effects models. Table 7 collects,  
52  
53 in columns (7) and (8), the results for the fixed effects model, while columns (9) and (10)  
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56  
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58 <sup>8</sup> First, in 1994 a number of changes took place. Economic circumstances were included in the reasons  
59  
60 justifying individual dismissal procedures, which made it easier to occur. Unemployment benefit would  
come to be considered as taxable income and a range of issues on working conditions were no longer  
regulated. In that year the principle of causality was also re-established as a general rule for fixed-term  
contracts. Then, in 1997 a new permanent contract with lower dismissals costs was approved.

1  
2  
3 refer to the random effects model. The results are basically consistent with the others  
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5 already obtained, meaning that high persistence unemployment exists even after controlling  
6  
7 for the elements of heterogeneity of the Spanish provinces.  
8  
9

10 **[Insert Table 7 about here]**  
11

12 Table 7 also shows, in Columns (11) and (12), the estimates obtained through the  
13 GMM technique of Arellano and Bond (1991) described in Section 3. The results were  
14  
15 computed using robust standard errors to avoid heteroskedasticity.<sup>9</sup> Given that we deal with  
16  
17 quarterly data, we have included in the model, as instruments, four lags of the dependent  
18  
19 variable. We also display in Table 7 the statistics for the first- and second-order  
20  
21 autocorrelation of the residuals ( $m_1$  and  $m_2$ , respectively). As expected, the residuals of the  
22  
23 estimated equation show first- but not second-order autocorrelation.<sup>10</sup>  
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29 In summary, panel data analysis enables us to state that UR persistence in Spain has  
30  
31 remained remarkably high in the last decades: the AR(1) coefficient is hovering around 0.95  
32  
33 for the majority of the estimated panel data models. It also suggests that the persistence  
34  
35 might have experienced a substantial decline in 1994. A drawback of applying Arellano and  
36  
37 Bond's (1991) procedure to our data set is that it is designed under the "classical" panel  
38  
39 setting, where  $T$  is small and  $N$  is large, which is not the case in the present work.  
40  
41 Moreover, it imposes stationarity, while previous results presented in this work indicated  
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43 that unemployment was nonstationary.<sup>11</sup>  
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48 Finally, we perform panel unit root tests, which provide dramatic improvements in  
49  
50 power compared to performing separate unit root tests for each individual series. In Table 8  
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53  
54 <sup>9</sup> On the other hand, the Sargan test from the one-step homoskedastic estimator rejected the null  
55 hypothesis that the over-identifying restrictions are valid, but this could be due to heteroskedasticity.

56  
57 <sup>10</sup> The presence of first-order autocorrelation in the differenced residuals does not imply that the estimates  
58 are inconsistent, while it would be the case if the second-order autocorrelation were found. See Arellano  
59 and Bond, 1991, pp. 281-2.

60  
<sup>11</sup> Note, however, that even with the novel techniques used here, it is still statistically difficult to  
distinguish between nonstationarity (with a unit root) and stationarity with AR coefficients close to the  
unit circle.

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3 we report the results of computing LLC (2002) procedure, while Table 9 shows the IPS  
4 (2003) unit root tests. The estimated coefficients of the intercepts, in the single-equation  
5 models in Table 7, exhibited important differences between regions and, therefore, a  
6 common constant for the whole panel should not be included. Instead, the estimations allow  
7 for heterogeneous intercepts.  
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15 **[Insert Table 8 about here]**  
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17 Recall that the ADF and DF-GLS tests for time series failed to reject the unit root  
18 null for all regions. However, the low power of these tests against the stationary alternative,  
19 when the process is near-integrated, is a well-known problem (see, for instance, León-  
20 Ledesma and McAdam, 2004). Now, using a panel data set, we apply more powerful  
21 procedures and benefit from a reasonable large panel, collecting 50 provinces and 114 time  
22 periods. The degree of persistence for each individual regression error is allowed to vary  
23 freely across the 50 provinces.  
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33 The LLC (2002) paper proves that their t-star statistic is standard normal under the  
34 null of nonstationarity. We have included in equation (10) as many lagged first differences,  
35 for each province, as indicated by  $k$  in Table 7. Since Table 7 was computed for the regions,  
36 we assume here the same  $k$  for all the provinces comprised in the same region.<sup>12</sup> The results  
37 in Table 8 indicate that, once again, we cannot reject the unit root null for aggregate Spanish  
38 unemployment, implying that the question about unemployment persistence in Spain finds  
39 again an affirmative answer. Next, we make up panels gathering all the provinces which  
40 belong to the same region,<sup>13</sup> even if most of them do not reach to the 8 or 10 individuals,  
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55 <sup>12</sup> The estimations based on different  $k$  for each individual (instead of enforcing the same  $k$  for all the  
56 provinces within the same region) yielded very similar results and are not shown.

57  
58 <sup>13</sup> The devise of grouping “ad hoc” sub-panels for particular purposes, has been applied even for the case  
59 of just a few individuals (Cf. Culver and Papell, 1997). The shorter is the panel, the more difficult is that  
60 the cross-section variation helps to reject the unit root null, but whenever it happens, the result is very  
strong. Note also that LLC (2002) test is to some extent accurate for small panels, since “the normal  
distribution provides a good approximation to the empirical distribution of the test statistic in relatively  
small samples”.

1  
2  
3 which is a minimum required to make an accurate implementation of the test. Then, we  
4  
5 gather the provinces in groups of 8 or 9, attending mainly to the value of  $k$  in Table 1.  
6  
7

8 It is meaningful the fact that there are some regional panels for which the unit root  
9  
10 null is not rejected.<sup>14</sup> Not surprisingly, they correspond precisely to those regions for which  
11  
12 fractional integration methods reported a greater degree of UR persistence: Cataluña, País  
13  
14 Vasco and Madrid. The corresponding P-value, for the model without time trend in column  
15  
16 (3), indicates that there is a certain significant probability of failure of rejecting the unit root  
17  
18 null, which is consistent with the finding that these three regions present the strongest  
19  
20 unemployment persistence. More significantly, the P-value for the panel gathering these  
21  
22 three regions together is as high as [0.031] for the model without trend.  
23  
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26  
27 Note, on one hand, that LLC (2002) test has been criticised for assuming, under the  
28  
29 alternative of stationarity, that all cross-sections converge to the equilibrium at the same  
30  
31 speed of adjustment. That should not be a serious problem in the present paper as far as we  
32  
33 are precisely interested in the cases in which we fail to reject the null hypothesis of unit  
34  
35 roots. On the other hand, if some degree of heterogeneity between panels exists, the  
36  
37 prescribed test procedure is the IPS (2003) unit root test. Even though the properties of both  
38  
39 types of tests depend upon the independence assumption across individuals, we venture that  
40  
41 they may be of some help in some applied studies like this.<sup>15</sup> The results of these tests,  
42  
43 shown in Table 9, yield basically the same conclusions than those in Table 8. In all the  
44  
45 models we have included 8 lagged first differences.<sup>16</sup> The tests clearly fail to reject the unit  
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53 <sup>14</sup> That is not the case for the majority of the regions, implying that the individual unemployment series  
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55 included in those regions should be considered  $I(0)$ . This panel-based test could not be carried out for the  
56  
57 case of regions containing a number of provinces smaller than 3.

58  
59 <sup>15</sup> As stressed by Strauss (2003), subtracting cross-sectional means to remove common time specific  
60  
effects is a quite common procedure but, if there is heterogeneity in the cross sectional correlation, it will  
only partially reduce the problem. Regarding the LLC test, it requires independence across individuals,  
assumption that can be somewhat relaxed to allow for some degree of dependence by including time-  
specific intercepts, which does not affect the limiting distributions of the test (Cf.: LLC, 2002, p. 13).

<sup>16</sup> Note that IPS (2003) pointed out that the tests perform better if the orders of the underlying ADF  
regressions are correctly chosen or over-estimated.

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3 root null both in the case of the national aggregate UR and for the panel that gathers the  
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5 three mentioned regions. Furthermore, this result occurs regardless whether the trend is  
6  
7 included or not. By comparing the last two rows of Table 9, IPS (2003) tests teach us that  
8  
9 the unit root for Valencia can be discarded.  
10  
11

## 12 13 14 15 **5. Concluding comments**

16  
17 In this paper we have examined the persistence of Spanish unemployment in the last  
18  
19 three decades, paying especial attention to the regional unemployment persistence.  
20  
21 From a time series viewpoint, we first computed ADF and DF-GLS unit root tests.  
22  
23 Then, we also measure UR persistence through the AR coefficients and by fractional  
24  
25 differencing parameters. The cross-section analysis consisted basically of running mean  
26  
27 regressions of regional UR. For the panel data methodology, we have employed a panel  
28  
29 of 114 periods and 50 provinces. We run regressions for the pooled model as well as for  
30  
31 the fixed and random effects models. The Arellano and Bond method for estimating  
32  
33 dynamic panels was applied too. Finally, we performed LLC (2002) and IPS (2003)  
34  
35 panel data unit root tests.  
36  
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41 Among other findings, this empirical analysis has taught us three major lessons.  
42  
43 First, that UR persistence (in aggregate as well as in regional terms) has been very  
44  
45 strong in Spain throughout the last 25 years. Second, that it experienced a decline  
46  
47 around 1994. Finally, that some of the most industrialized areas, like Cataluña, Madrid  
48  
49 and País Vasco, endure the greatest unemployment persistence across the sample. These  
50  
51 three regions are also the areas that present the smallest share of the labour force in  
52  
53 agriculture and where the proportion of population living in large cities is among the  
54  
55 greatest across the country.  
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59  
60 Regarding the first conclusion, the high level of persistence at both aggregate  
and regional level in Spain is probably similar to the Italian experience, whereas it is in

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3 sharp contrast with other European countries or with the US (Cf. Jimeno and Bentolila,  
4  
5 1998). This feature might suggest that there are some types of idiosyncratic factors  
6  
7 (common to other Southern European countries) that explain the high persistence of  
8  
9 unemployment. Even considering the reforms carried out in the Spanish labour market  
10  
11 in 1994 and 1997, rigidities might have prevailed due to the inertia of legislation that  
12  
13 has only recently been annulled.  
14  
15

16  
17 However, other authors consider that institutional factors are not the main  
18  
19 sources provoking high unemployment. Bertola and Ichino (1995) argue that, since  
20  
21 institutional rigidities already existed in the past, other factors ought to be invoked to  
22  
23 explain the high UR experienced in Europe since the middle 1980s. On their view, both  
24  
25 the high unemployment in Europe and the increasing wage dispersion in the US must  
26  
27 stem from the same cause. Then, institutional rigidities would have only triggered the  
28  
29 process leading to high UR, but other forces (like a more rapid idiosyncratic shocks  
30  
31 between sectors, suggested by Lilien, 1982) must be the ultimate cause of it.  
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35  
36 For the case of Spain, geographic labour mobility should certainly be taken into  
37  
38 account. Since the time in which Spain became a democratic country in 1975, a  
39  
40 persistent characteristic of its labour market has been the low rate of interregional  
41  
42 immigration, despite of the disparities in the UR across regions (Jimeno and Bentolila,  
43  
44 1998). Garcia-Rubiales (2005) moves along the same position when states that Spanish  
45  
46 unemployment is more closely linked to the lack of labour mobility than to institutional  
47  
48 rigidities.<sup>17</sup> We venture that the lack of labour mobility across Spanish regions could be  
49  
50 the root of not just of high UR level but also of high unemployment persistence. Note  
51  
52 that they are different concepts, since high persistence in a region can be experienced  
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<sup>17</sup> This can be related to the number of temporary jobs too. Spain is the EU member with the highest level of temporary employment, which affects the duration distribution of unemployment (Cf. Guell, 2003).

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3 accompanied by low UR. And yet, the fact is that high UR become more harmful as  
4  
5 long as it coexists with high UR persistence.  
6

7  
8 Other meaningful finding of this study is the lower unemployment persistence  
9  
10 experienced in Spain from the middle 1990s onwards. Why did such a decline in  
11  
12 unemployment persistence occur around 1994? We have already mentioned that  
13  
14 important labour market reforms were introduced precisely in that year. Besides that, by  
15  
16 1994 Spain had already had time enough to accommodate its integration into the EU  
17  
18 (1986) and the EMS (1989). Besides, note that other important institutional changes  
19  
20 took place at that time, linked to government changes coming from the European,  
21  
22 regional and general elections of 1994, 1995 and 1996, respectively.  
23  
24  
25

26  
27 According to the report for Spain of the European Commission (2005, p. 5):  
28  
29 *“High and persistent unemployment prompted a labour market reform in 1984, which was*  
30  
31 *instrumental to job creation. During the economic boom in the second half of the eighties, the*  
32  
33 *UR went down to around 16% in 1991. Labour rigidities, which enhanced the persistence of*  
34  
35 *adverse shocks (Dolado and Jimeno, 1997) coupled with the incorporation of the baby boom*  
36  
37 *cohorts and women into the labour market in the late 80s and the early 90s, pushed the UR*  
38  
39 *above 20% in the 1993 slowdown. Since the second half of the 90s the UR fell significantly*  
40  
41 *below 15% to nearly 11% in 2003 (...). Moreover, the resilience of employment growth has*  
42  
43 *been particularly impressive during the last ten years. Since 1995, more than 25% of the total*  
44  
45 *net job creation in the euro area was registered in Spain. Such (un)employment performance*  
46  
47 *could point to a major structural change with respect to the past”.*

48  
49 The previous comments are basically consistent with our empirical findings.  
50  
51 Since 1995, the Spanish employment rate has increased briskly by more than 13%,  
52  
53 standing now close to 60%. This might be the main reason for the structural break that  
54  
55 we have found around 1994. Moreover, the UR in Spain, although still the highest in the  
56  
57 Euro-area, has been steadily falling from its peak of around 23% in 1994 to slightly  
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59 above 11% in 2003. The positive change in labour market outcomes with respect to past  
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trends might also be explained by: (i) the stability-oriented policies associated to the  
EMU membership; (ii) the labour market reforms as well as the moderation in nominal



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3 unit labour costs; and (iii) the expansion of some labour-intensive sectors (construction  
4 and some services), which have significantly contributed to sustain employment growth.  
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7  
8 Finally, we have found greater persistence in some regions, namely: Cataluña,  
9 Madrid and País Vasco (and, in a minor extent, in Valencia and Aragón). The reasons  
10 for this evidence are not straightforward. In any case, the issue must be placed into the  
11 context of regional unemployment divergence between regions, since there are large  
12 disparity in the geographical distribution of UR. Andalucía and Extremadura recorded  
13 the highest UR in 2004, around 18%; whereas the opposite geographical and socio-  
14 economic extremes, Navarra and La Rioja, registered rates about 5%. Madrid exhibited  
15 a rate of 6.5% and Cataluña and País Vasco of about 9%.  
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27 The study accomplished by the European Commission (2005) justifies the  
28 disparities across regions on the bases of low geographical mobility of the labour force,  
29 which in turn is amplified by the characteristics of the housing market (poor  
30 development of rental housing, etc.). However, regardless of the origin of such  
31 persistence in regional unemployment dispersion, it does not explain why Madrid,  
32 Cataluña and País Vasco are the regions with greater unemployment persistence. The  
33 first one is by far the region in which a bigger proportion of the population lives in large  
34 cities, while the other two are among the most industrialized regions in Spain. These are  
35 also the three regions in which the smallest percentage of labour force is enrolled in the  
36 agriculture sector. Further study must be done to explain the causes behind this facts.  
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## Appendix A

The LM test of Robinson (1994) for testing  $H_0: d = d_0$  in a model given by

$$u_t = \beta' z_t + x_t, \quad t = 1, 2, \dots \quad (\text{A1})$$

and (8) is:

$$\hat{r} = \frac{T^{1/2}}{\hat{\sigma}^2} \hat{A}^{-1/2} \hat{a},$$

where  $T$  is the sample size and:

$$\hat{a} = \frac{-2\pi}{T} \sum_{j=1}^{T-1} \psi(\lambda_j) g(\lambda_j; \hat{\tau})^{-1} I(\lambda_j); \quad \hat{\sigma}^2 = \sigma^2(\hat{\tau}) = \frac{2\pi}{T} \sum_{j=1}^{T-1} g(\lambda_j; \hat{\tau})^{-1} I(\lambda_j);$$

$$\hat{A} = \frac{2}{T} \left( \sum_{j=1}^{T-1} \psi(\lambda_j)^2 - \sum_{j=1}^{T-1} \psi(\lambda_j) \hat{\varepsilon}(\lambda_j)' \times \left( \sum_{j=1}^{T-1} \hat{\varepsilon}(\lambda_j) \hat{\varepsilon}(\lambda_j)' \right)^{-1} \times \sum_{j=1}^{T-1} \hat{\varepsilon}(\lambda_j) \psi(\lambda_j) \right)$$

$$\psi(\lambda_j) = \log \left| 2 \sin \frac{\lambda_j}{2} \right|; \quad \hat{\varepsilon}(\lambda_j) = \frac{\partial}{\partial \tau} \log g(\lambda_j; \tau); \quad \lambda_j = \frac{2\pi j}{T}; \quad \hat{\tau} = \arg \min \sigma^2(\tau).$$

Note that  $z_t$  in (A1) is a  $(k \times 1)$  vector of deterministic variables that might include an intercept (i.e.  $z_t = 1$ ) or an intercept and a linear time trend. Also,  $\hat{a}$  and  $\hat{A}$  in the above expressions are obtained through the first and second derivatives of the log-likelihood function with respect to  $d$  (see Robinson, 1994, page 1422, for further details).  $I(\lambda_j)$  is the periodogram of  $u_t$  evaluated under the null, i.e.:

$$\hat{v}_t = (1 - L)^{d_0} u_t - \hat{\beta}' w_t; \quad \hat{\beta} = \left( \sum_{t=1}^T w_t w_t' \right)^{-1} \sum_{t=1}^T w_t (1 - L)^{d_0} u_t; \quad w_t = (1 - L)^{d_0} z_t,$$

and  $g$  is a known function related to the spectral density function of  $u_t$ :

$$f(\lambda; \sigma^2; \tau) = \frac{\sigma^2}{2\pi} g(\lambda; \tau), \quad -\pi < \lambda \leq \pi.$$

## Appendix B

The Whittle estimate of Robinson (1995) is implicitly defined by:

$$\hat{d} = \arg \min_d \left( \log \overline{C(d)} - 2d \frac{1}{m} \sum_{j=1}^m \log \lambda_j \right), \quad (\text{B1})$$

$$\text{for } d \in (-1/2, 1/2); \quad \overline{C(d)} = \frac{1}{m} \sum_{j=1}^m I(\lambda_j) \lambda_j^{2d}, \quad \lambda_j = \frac{2\pi j}{T}, \quad \frac{m}{T} \rightarrow 0.$$

where  $m$  is a bandwidth parameter number.

### Appendix C

The starting model in Hsu and Kuan (2004) is:

$$u_t = \begin{cases} \mu_1 + x_t, & t = 1, 2, \dots, T_b \\ \mu_2 + x_t, & t = T_b + 1, \dots, T \end{cases}, \quad (C1)$$

where  $T_b$  is unknown and  $x_t$  is given by (1). The procedure is simple. For each hypothetical change point ( $T_b$ ) we estimate first  $\mu_1$  and  $\mu_2$  in (C1) from the pre- and post-change observations, i.e

$$\mu_1 = \frac{1}{T_b} \sum_{t=1}^{T_b} u_t; \text{ and } \mu_2 = \frac{1}{T-T_b} \sum_{t=T_b+1}^T u_t.$$

The residuals are

$$\hat{x}_t = \begin{cases} u_t - \hat{\mu}_1, & t = 1, 2, \dots, T_b \\ u_t - \hat{\mu}_2, & t = T_b + 1, \dots, T \end{cases},$$

and the periodogram of  $\hat{x}_t$ , (evaluated at the discrete Fourier frequencies,  $\lambda_j = 2\pi j/T$ ) is given by:

$$I_{\hat{x}}(\lambda_j) = \frac{1}{2\pi T} \left| \sum_{t=1}^T \hat{x}_t e^{i\lambda_j t} \right|^2.$$

Then, for each change point  $T_b$ , an estimate of  $d$  can be obtained by minimizing the Whittle function in the frequency domain, using a band of frequencies that degenerates to zero, (see, e.g., Robinson, 1995), i.e.,

$$\hat{d}(T_b) = \arg \min_d L(d(T_b), T_b) = \arg \min_d \left( \log \overline{C(d)} - 2d \frac{1}{m} \sum_{j=1}^m \log \lambda_j \right),$$

$$\text{for } d \in (-1/2, 1/2); \overline{C(d)} = \frac{1}{m} \sum_{j=1}^m I_{\hat{x}}(\lambda_j) \lambda_j^{2d}, \lambda_j = \frac{2\pi j}{T}, \frac{m}{T} \rightarrow 0,$$

where  $m$  is a bandwidth parameter number. The change point estimator  $\tilde{T}_b$  is then

$$\arg \min_{T_b} L(\hat{d}(T_b); T_b)$$

where  $T_b \in [T_1, T_2] \subseteq (1, T)$ , and the estimator for  $d$  is  $\tilde{d}(\tilde{T}_b)$ . Hsu and Kuan (1998) showed that under very mild regularity conditions  $\tilde{T}_b$  is a consistent estimate for  $T_b$  and thus, following Robinson (1995),

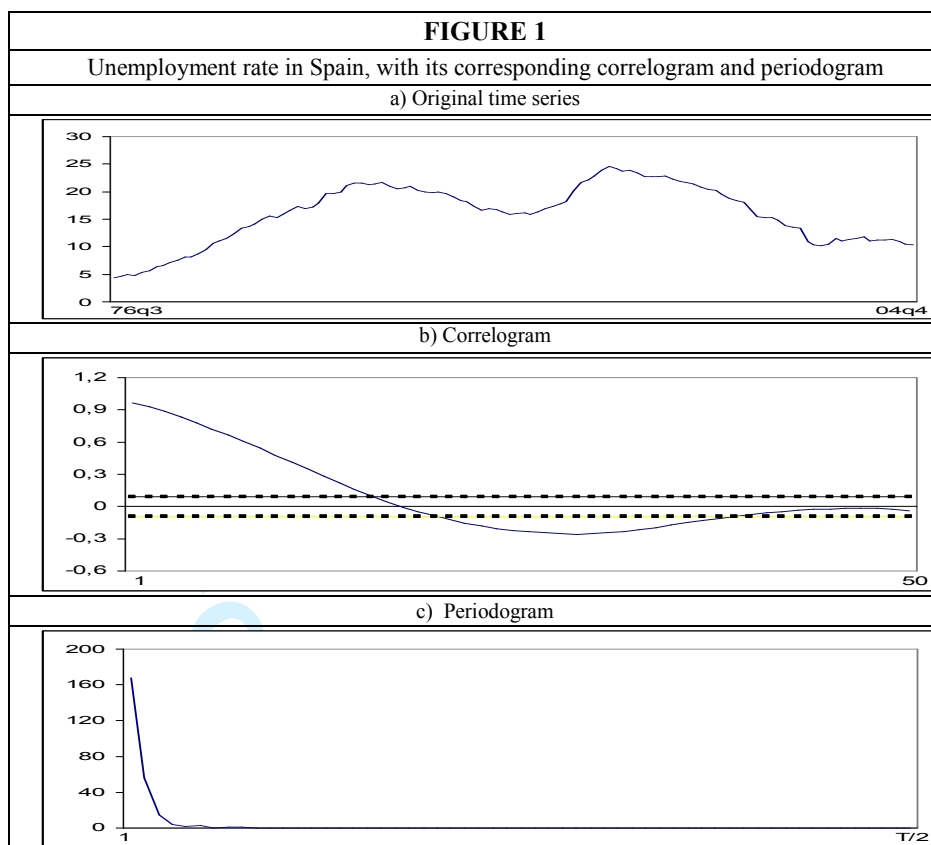
$$\sqrt{m} (\hat{d} - d_o) \rightarrow_d N(0, 1/4) \quad \text{as } T \rightarrow \infty.$$

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The large sample standard error under the null hypothesis of no autocorrelation is  $1/\sqrt{T}$ . The periodogram was computed based on the discrete Fourier frequencies  $\lambda_j = 2\pi j/T$ .

**TABLE 1**  
ADF unit root test (1976q3:2004q4)

Critical values	Without trend			With trend		
	1%	5%	10%	1%	5%	10%
ADF <sup>a</sup>	-3.51	-2.89	-2.58	-4.04	-3.45	-3.15
DF-GLS (ERS) <sup>b</sup>	-2.60	-1.95	-1.61	-3.56	-3.02	-2.73
	(1)	(2)	(3)	(4)	(5)	(6)
	$k$	$t_\alpha(\text{ADF})$	$t_\alpha(\text{dfgls})^c$	$k$	$t_\alpha(\text{ADF})$	$t_\alpha(\text{dfgls})^c$
TOTAL	10	-1.99	-0.88	8	-2.30	-1.52
ANDALUCIA	4	-1.71	-0.76	5	-1.23	-0.91
ARAGON	9	-1.71	-0.98	9	-1.94	-1.08
ASTURIAS	0	-2.07	-0.70	9	-1.56	-0.96
BALEARES	12	<b>-2.87</b>	-1.10	12	-2.89	-1.63
CANARIAS	12	-1.98	-1.15	12	-2.06	-1.36
CANTABRIA	9	<b>-2.60</b>	-0.95	11	-2.36	-1.82
CASTILLA-LEON	4	-2.08	-0.82	12	-1.44	-1.16
CASTILLA-MANCHA	12	-2.57	-1.02	12	-2.31	-1.70
CATALUÑA	8	<b>-2.81</b>	-1.40	8	<b>-3.17</b>	-1.86
COM.VALENCIANA	7	-2.35	-0.90	7	-2.14	-1.19
EXTREMADURA	10	-1.88	-0.53	10	-1.10	-0.70
GALICIA	10	-2.37	-0.46	10	-1.12	-1.02
MADRID	8	-2.29	-1.37	8	-2.39	-1.75
MURCIA	8	-2.37	-1.10	8	-2.05	-1.43
NAVARRA	8	-1.88	-1.27	8	<b>-3.29</b>	-1.37
PAIS VASCO	4	-2.27	-0.92	6	-2.27	-1.31
RIOJA	8	-2.30	-1.14	8	-2.19	-1.37

a ADF: interpolated Dickey-Fuller critical values.

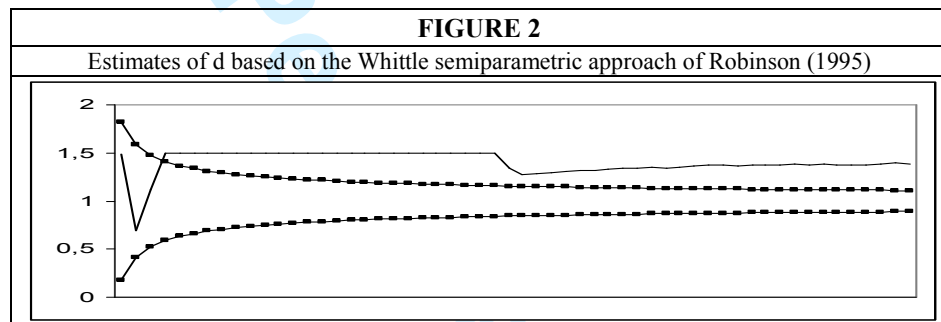
b ERS: represent interpolated critical values from Elliot, Rothenberg, and Stock.

c Modified Dickey-Fuller  $t$ -test for a unit root in which the series has been transformed by a GLS regression. These are appropriate to be confronted with the ERS critical values.

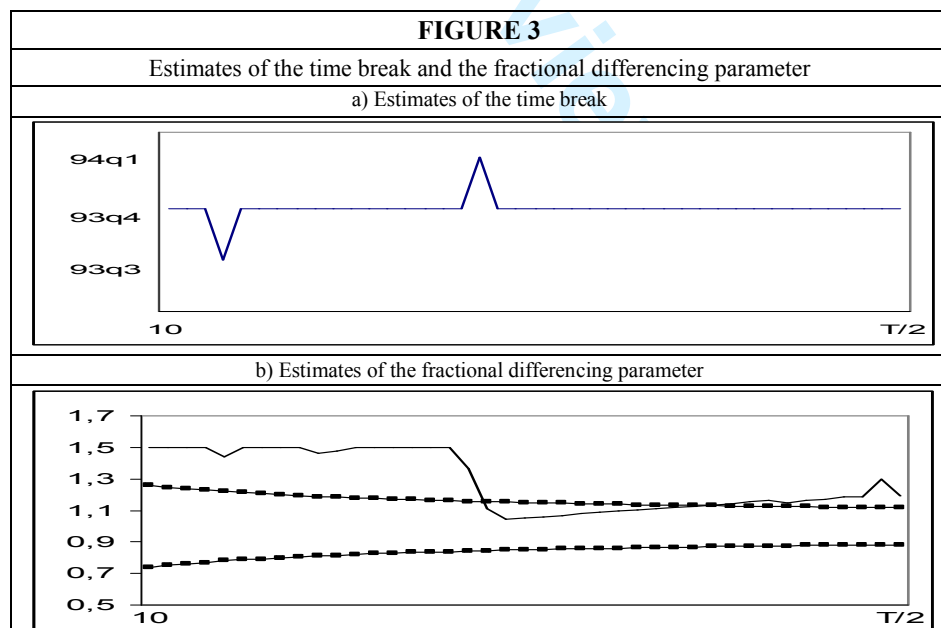
TABLE 2					
Unemployment persistence in Spain. Aggregated and disaggregated by regions (1976q3:2004q4)					
	d = 0		Estimates of d		
	AR (1)	Seasonal AR(1)	White noise	Bloomfield (1)	Seasonal AR(1)
TOTAL	0.9944	0.9518	<b>1.381<sup>a</sup></b>	<b>1.318<sup>a</sup></b>	<b>1.321<sup>a</sup></b>
ANDALUCIA	0.9901	0.9493	<b>1.103<sup>a</sup></b>	1.136	1.041
ARAGON	0.9839	0.9157	<b>1.104<sup>a</sup></b>	<b>1.250<sup>a</sup></b>	1.053
ASTURIAS	0.9802	0.9146	1.014	1.050	0.999
BALEARES	0.8360	0.8555	0.668 <sup>b</sup>	0.314 <sup>b</sup>	0.699 <sup>b</sup>
CANARIAS	0.9869	0.9382	1.078	<b>1.128<sup>a</sup></b>	1.068
CANTABRIA	0.9845	0.9281	1.059	1.092	1.045
CASTILLA-LEON	0.9905	0.9575	1.092 <sup>a</sup>	1.047	0.996
CASTILLA-MANCHA	0.9798	0.9356	1.016	0.969	0.939
CATALUÑA	0.9907	0.9241	<b>1.315<sup>a</sup></b>	<b>1.363<sup>a</sup></b>	<b>1.239<sup>a</sup></b>
COM.VALENCIANA	0.9904	0.9397	<b>1.166<sup>a</sup></b>	<b>1.496<sup>a</sup></b>	1.088
EXTREMADURA	0.9694	0.9141	0.881	0.811 <sup>b</sup>	0.849
GALICIA	0.9888	0.9617	1.035	0.897	0.979
MADRID	0.9875	0.9180	<b>1.205<sup>a</sup></b>	<b>1.289<sup>a</sup></b>	<b>1.165<sup>a</sup></b>
MURCIA	0.9761	0.9214	0.942	1.125	0.899
NAVARRA	0.9710	0.9280	0.932	1.025	0.827 <sup>b</sup>
PAIS VASCO	0.9935	0.9580	<b>1.201<sup>a</sup></b>	<b>1.408<sup>a</sup></b>	<b>1.137<sup>a</sup></b>
RIOJA	0.9706	0.8890	0.984	1.060	0.956

a Rejections of the null hypothesis  $d = 1$  in favour of  $d > 1$ . (Also in bold)

b Rejections of the null hypothesis  $d = 1$  in favour of  $d < 1$ .

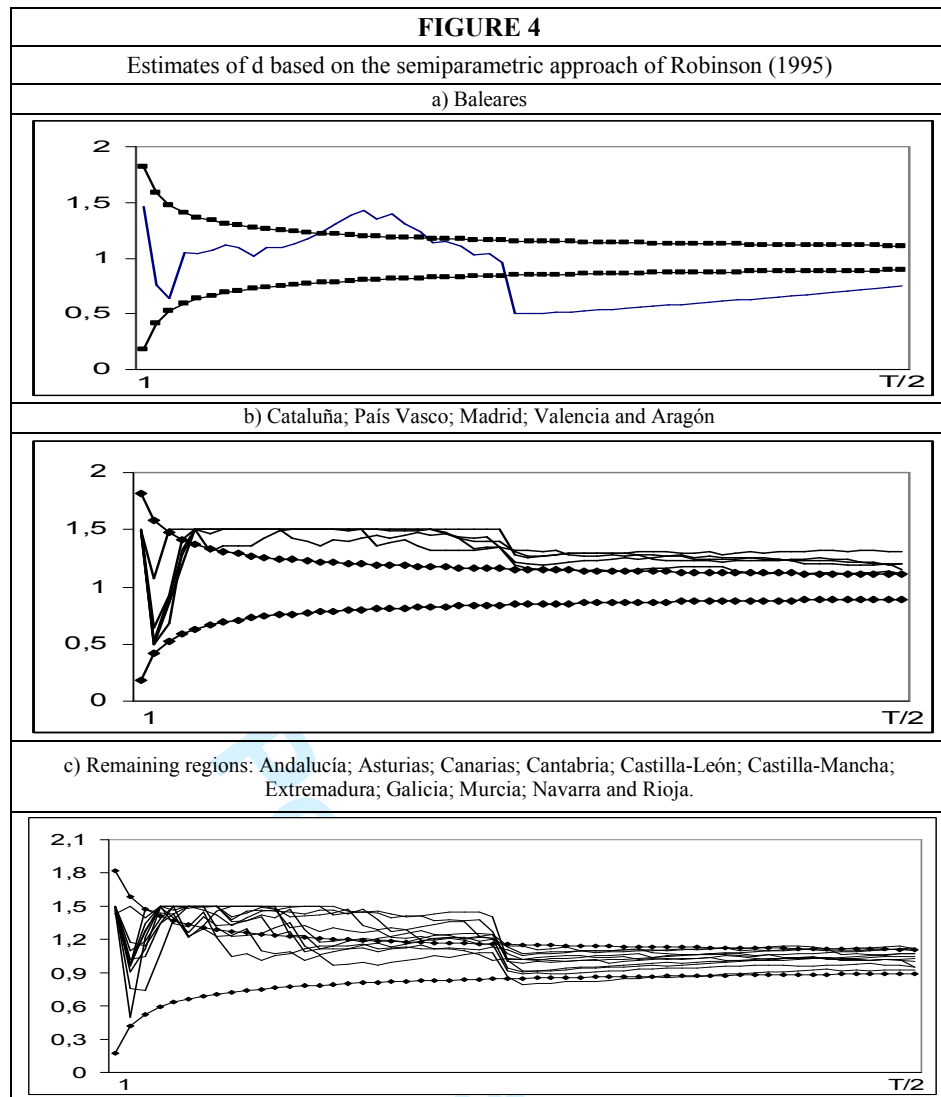


The horizontal axe refers to the bandwidth number while the vertical one corresponds to the estimates of  $d$ .



The horizontal axe refers to the bandwidth number  $m$  while the vertical is the estimated time break in the upper plot and the estimated values of  $d$  in the lower plot. In the latter, we also include the 95% confidence interval of the  $I(1)$  hypothesis.





The horizontal axe refers to the bandwidth number while the vertical one corresponds to the estimates of  $d$ .

Unemployment persistence: Aggregated and disaggregated by regions with data ending at 1993q4					
	$d = 0$		Estimates of $d$		
	AR (1)	Seasonal AR(1)	White noise	Bloomfield (1)	Seasonal AR(1)
TOTAL	0.9976	0.9668	<b>1.402</b>	<b>1.342</b>	<b>1.336</b>
ANDALUCIA	0.9945	0.9629	1.02	<b>1.25</b>	0.97
ARAGON	0.9880	0.9204	1.06	<b>1.30</b>	1.00
ASTURIAS	0.9937	0.9631	1.00	0.90	0.97
BALEARES	0.8728	0.8888	0.55	0.29	0.56
CANARIAS	0.9925	0.9640	0.97	0.95	0.93
CANTABRIA	0.9926	0.9560	0.94	1.00	0.94
CASTILLA-LEON	0.9946	0.9747	0.97	0.73	0.98
CASTILLA-MANCHA	0.9883	0.9480	0.97	0.82	0.91
CATALUÑA	0.9939	0.9237	<b>1.38</b>	<b>1.51</b>	<b>1.29</b>
COM.VALENCIANA	0.9957	0.9588	<b>1.19</b>	1.48	<b>1.12</b>
EXTREMADURA	0.9788	0.9424	0.67	0.53	0.64
GALICIA	0.9964	0.9777	0.99	0.76	0.91
MADRID	0.9884	0.8967	<b>1.20</b>	<b>1.33</b>	1.14
MURCIA	0.9891	0.9449	0.91	0.83	<b>0.91</b>
NAVARRA	0.9631	0.9138	0.89	0.98	0.78
PAIS VASCO	0.9962	0.9691	1.12	<b>1.49</b>	1.04
RIOJA	0.9759	0.8994	0.93	<b>1.20</b>	0.87

In bold those values which are higher than in Table 3 (based on whole sample size).

FIGURE 5

Provincial Unemployment Rates for 1988, 1994, 2000 and 2004 with respect to 1976

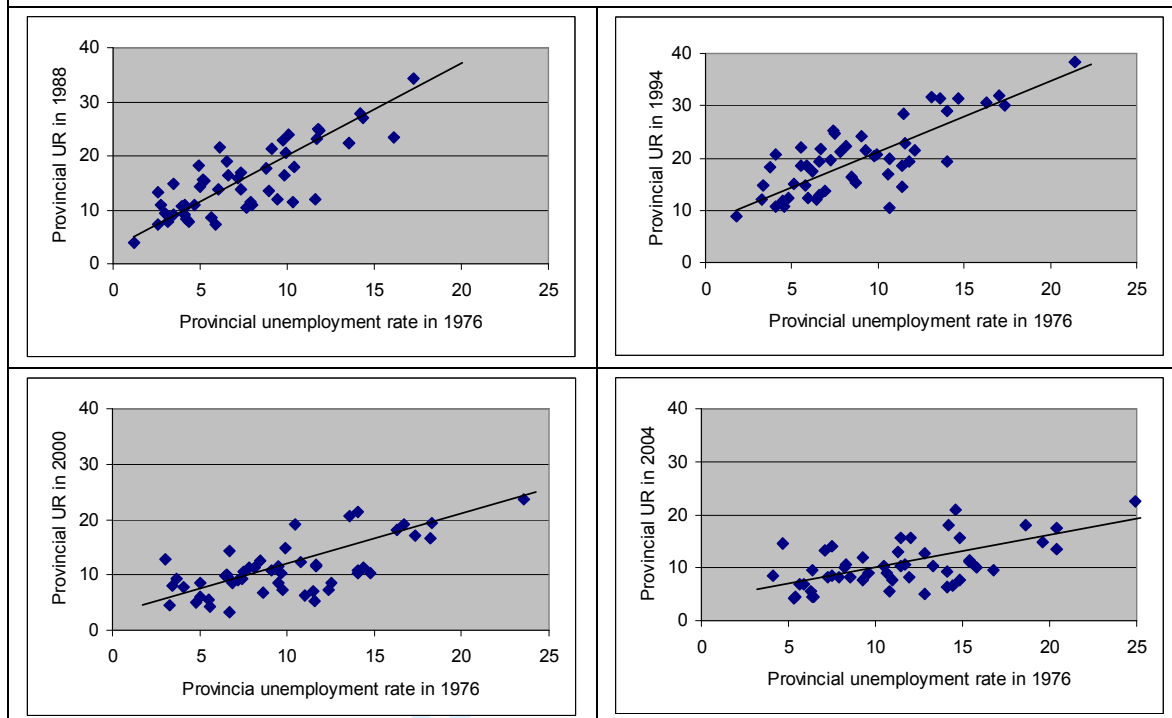


TABLE 4

Regressions of Unemployment Rates for provinces with respect to previous years

	Dependent variable: UR (annual averages for provinces)				
	1982	1988	1994	2000	2004
1976	<b>1.288</b> (8.44)	<b>1.914</b> (10.5)	<b>1.925</b> (8.93)	<b>1.449</b> (6.60)	<b>0.960</b> (5.89)
	$R^2 = 0.597$	$R^2 = 0.696$	$R^2 = 0.624$	$R^2 = 0.475$	$R^2 = 0.419$
1982		<b>1.176</b> (11.4)	<b>1.146</b> (8.77)	<b>0.715</b> (4.78)	<b>0.474</b> (4.36)
		$R^2 = 0.731$	$R^2 = 0.615$	$R^2 = 0.322$	$R^2 = 0.284$
1988			<b>0.978</b> (16.3)	<b>0.751</b> (9.91)	<b>0.487</b> (7.94)
			$R^2 = 0.847$	$R^2 = 0.671$	$R^2 = 0.567$
1994				<b>0.744</b> (11.8)	<b>0.516</b> (11.0)
				$R^2 = 0.745$	$R^2 = 0.719$
2000					<b>0.650</b> (16.5)
					$R^2 = 0.850$

Estimations computed for the annual average unemployment rates. Coefficients in bold at the 95% level. (*t*-statistic) in parenthesis.

TABLE 5

Mean regression of UR for provinces in Spain: $\Delta u^i = \alpha + \beta u^i_q + \varepsilon$					
	(1)	(2)	(3)	(4)	(5)
After:	$q = 1976$	$q = 1982$	$q = 1988$	$q = 1994$	$q = 2000$
1 year	0.087 (1.64)	0.035 (0.83)	-0.025 (-0.66)	-0.013 (-0.37)	<b>-0.317</b> (-6.74)
2 years	0.071 (0.93)	<b>0.303</b> (3.62)	-0.087 (-1.63)	-0.062 (-1.49)	<b>-0.217</b> (-5.61)
4 years	0.247 (1.88)	<b>0.254</b> (2.74)	-0.093 (-1.64)	<b>-0.143</b> (-2.35)	<b>-0.349</b> (-8.87)
6 years	0.288 (1.89)	0.176 (1.71)	-0.021 (-0.37)	<b>-0.255</b> (-4.06)	
8 years	<b>0.916</b> (4.50)	0.069 (0.58)	-0.067 (-1.00)	<b>-0.380</b> (-7.45)	
10 years	<b>0.982</b> (5.38)	0.011 (0.08)	-0.115 (-1.61)	<b>-0.483</b> (-10.3)	
12 years	<b>0.914</b> (5.01)	0.146 (1.12)	<b>-0.248</b> (-3.28)		
14 years	<b>0.760</b> (3.73)	0.015 (0.10)	<b>-0.389</b> (-6.00)		
16 years	<b>0.816</b> (4.16)	-0.061 (-0.41)	<b>-0.512</b> (-8.35)		
18 years	<b>0.925</b> (4.29)	-0.284 (-1.90)			
20 years	<b>0.793</b> (3.48)	<b>-0.380</b> (-3.14)			
22 years	<b>0.774</b> (3.56)	<b>-0.525</b> (-4.84)			
24 years	<b>0.449</b> (2.05)				
26 years	0.243 (1.39)				
28 years	-0.039 (-0.24)				

Estimations computed for the annual average unemployment rates. Coefficients in bold at the 95% level. (*t*-statistic) in parenthesis. *i* denotes province,  $u^i_q$  is the UR in the starting period *q*, and  $\Delta u^i$  is the variation of the UR over the following *t* periods.

TABLE 6

Spanish unemployment persistence. Panel data estimations (1976q3-2004q4)						
	(1)	(2)	(3)	(4)	(5)	(6)
Variables	OLS	OLS	OLS	GLS	GLS	GLS
AR(1)	<b>0.9663</b> (269.2)	<b>0.9655</b> (217.5)	<b>0.9285</b> (152.4)	<b>0.9735</b> (373.8)	<b>0.9776</b> (308.4)	<b>0.9607</b> (230.7)
Break1982	-	0.0628 (0.86)	<b>0.4108</b> (4.72)	-	-0.0698 (-1.11)	0.0887 (1.31)
Break1988	-	0.0149 (0.19)	0.0205 (0.27)	-	-0.0075 (-0.14)	-0.0123 (-0.22)
Break1994	-	<b>-0.4628</b> (-5.92)	<b>-0.3832</b> (-4.88)	-	<b>-0.4933</b> (-9.04)	<b>-0.4575</b> (-8.28)
Break2000	-	<b>-0.1892</b> (-2.11)	<b>-0.0494</b> (-5.12)	-	-0.0267 (-0.42)	<b>-0.1675</b> (-2.50)
Constant	<b>0.5572</b> (11.70)	<b>0.7171</b> (15.02)	<b>0.6255</b> (5.24)	<b>0.4133</b> (10.29)	<b>0.6114</b> (13.21)	<b>0.5553</b> (4.67)
Reg.dummies	-	-	Yes	-	-	Yes
$R^2$	0.9456	0.9467	0.9476	-	-	-
N° periods	113	113	113	113	113	113
N° provinces	50	50	50	50	50	50
N°	5650	5650	5650	5650	5650	5650

Coefficients in bold at the 95% level. (*t*-statistic) in parenthesis. [*P*-value] in brackets.

TABLE 7

Spanish unemployment persistence. Panel data estimations (1976q3-2004q4)

	(7)	(8)	(9)	(10)	(11)	(12)
Variables	Fixed Effects	Fixed Effects	Random Effects. ML	Random Effects ML	GMM	GMM
AR(1)	<b>0.9341</b> (221.3)	<b>0.8839</b> (135.5)	<b>0.9515</b> (182.4)	<b>0.9060</b> (121.6)	<b>0.9470</b> (67.17)	<b>0.8577</b> (20.92)
Break1982	–	<b>0.8294</b> (8.69)	–	<b>0.6219</b> (6.14)	–	0.4662 (1.33)
Break1988	–	0.0271 (0.38)	–	0.0238 (0.33)	–	<b>–0.5710</b> (–4.78)
Break1994	–	<b>–0.2874</b> (–3.94)	–	<b>–0.3349</b> (–4.57)	–	<b>–0.8634</b> (–7.97)
Break2000	–	<b>–0.8623</b> (–9.25)	–	<b>–0.6801</b> (–6.95)	–	<b>–1.6972</b> (–4.10)
Constant	<b>1.0380</b> (15.41)	<b>1.3577</b> (18.45)	<b>0.7771</b> (8.95)	<b>1.1842</b> (11.32)	<b>–0.0016</b> (–1.76)	<b>0.0278</b> (–8.08)
R <sup>2</sup>	0.8974	0.9013	–	–	–	–
N° time periods	113	113	113	113	112	112
N° provinces	50	50	50	50	50	50
N° observations	5650	5650	5650	5650	5600	5600
Individual effects	[0.000] <sup>a</sup>	[0.000] <sup>a</sup>	[0.001] <sup>b</sup>	[0.000] <sup>b</sup>	–	–
m <sub>1</sub>					[0.003]	[0.001]
m <sub>2</sub>					[0.783]	[0.767]

Coefficients in bold at the 95% level. (*t*-statistic) in parenthesis. [P-value] in brackets.a: F-test that all  $u_i = 0$  ( $H_0$ : no fixed effects). b: likelihood ratio test of  $\sigma_u = 0$  ( $H_0$ : no random effects).m<sub>i</sub>: (i-order correlation test): Arellano-Bond test that average autocovariance in residuals of order  $i$  is 0. ( $H_0$ : no autocorrelation).

TABLE 8

Levin-Lin-Chu (2002) Panel unit root test (1976q3:2004q4)

	(1)	Constant		Constant & trend	
	(1)	(2)	(3)	(4)	(5)
	N <sup>a</sup>	<i>t</i> -star <sup>b</sup>	P-value	<i>t</i> -star <sup>b</sup>	P-value
SPAIN	50	<b>–0.288</b>	<b>[0.386]</b>	<b>0.571</b>	<b>[0.715]</b>
SPAIN (1976q3:1993q4)	50	<b>–2.242</b>	<b>[0.012]</b>	<b>0.962</b>	<b>[0.832]</b>
ANDALUCIA	8	–11.35	[0.000]	–15.57	[0.000]
ARAGON	3	–3.001	[0.001]	–4.770	[0.000]
ASTURIAS	1	–	–	–	–
BALEARES	1	–	–	–	–
CANARIAS	2	–	–	–	–
CANTABRIA	1	–	–	–	–
CASTILLA-LEON	9	–7.195	[0.000]	–9.976	[0.000]
CASTILLA-MANCHA	5	–3.119	[0.000]	–5.208	[0.000]
CATALUÑA	4	<b>–1.831</b>	<b>[0.033]</b>	–4.405	[0.000]
COM.VALENCIANA	3	–2.838	[0.002]	–3.269	[0.000]
EXTREMADURA	2	–	–	–	–
GALICIA	4	–4.235	[0.000]	–5.094	[0.000]
MADRID	1	–	–	–	–
MURCIA	1	–	–	–	–
NAVARRA	1	–	–	–	–
PAIS VASCO	3	<b>–2.302</b>	<b>[0.011]</b>	–4.902	[0.000]
RIOJA	1	–	–	–	–
BALEARES & CANARIAS & CAST-MANCHA	8	–3.128	[0.000]	–4.900	[0.000]
EXTREMADURA & GALICIA & ARAGON	9	–4.394	[0.000]	–8.373	[0.000]
MURCIA & NAVARRA & RIOJA & ASTURIAS & CANTABRIA & ARAGON	8	–4.494	[0.000]	–6.506	[0.000]
CATALUÑA & MADRID & VALENCIA	8	–2.874	[0.002]	–5.208	[0.000]
CATALUÑA & MADRID & PAIS VASCO	8	<b>–1.858</b>	<b>[0.031]</b>	–4.801	[0.000]

a Indicates the number of provinces included in each panel. The total number of observations is  $N \cdot (114 - k)$ .b Adjusted *t*-statistic, derived by LLC (2002), that obeys asymptotically the standard normal distribution.

TABLE 9

Im-Pesaran-Sin (2003) Panel unit root test (1976q3:2004q4)

	Constant			Constant & trend	
	(1)	(2)	(3)	(4)	(5)
	$N^a$	$t\text{-bar}^b$	$P\text{-value}$	$t\text{-bar}^b$	$P\text{-value}$
SPAIN	50	<b>-2.173</b>	<b>[0.015]</b>	<b>0.571</b>	<b>[0.715]</b>
SPAIN (1976q3:1993q4)	50	<b>-0.205</b>	<b>[0.419]</b>	<b>-0.590</b>	<b>[0.277]</b>
ANDALUCIA	8	-11.24	[0.000]	-11.57	[0.000]
ARAGON	3	-2.400	[0.001]	-2.990	[0.001]
ASTURIAS	1	-	-	-	-
BALEARES	1	-	-	-	-
CANARIAS	2	-	-	-	-
CANTABRIA	1	-	-	-	-
CASTILLA-LEON	9	-6.126	[0.000]	-6.147	[0.000]
CASTILLA-MANCHA	5	-2.697	[0.004]	-3.050	[0.001]
CATALUÑA	4	<b>-2.570</b>	<b>[0.005]</b>	-2.809	[0.002]
COM.VALENCIANA	3	-2.693	[0.004]	<b>-1.395</b>	<b>[0.081]</b>
EXTREMADURA	2	-	-	-	-
GALICIA	4	-3.964	[0.000]	-2.978	[0.001]
MADRID	1	-	-	-	-
MURCIA	1	-	-	-	-
NAVARRA	1	-	-	-	-
PAIS VASCO	3	<b>-2.302</b>	<b>[0.011]</b>	-4.902	[0.000]
RIOJA	1	-	-	-	-
BALEARES & CANARIAS & CAST-MANCHA	8	-3.056	[0.001]	<b>-2.247</b>	<b>[0.012]</b>
EXTREMADURA & GALICIA & ARAGON	9	-3.959	[0.000]	-5.922	[0.000]
MURCIA & NAVARRA & RIOJA & ASTURIAS & CANTABRIA & ARAGON	8	-4.366	[0.000]	-3.956	[0.000]
CATALUÑA & MADRID & VALENCIA	8	-4.380	[0.000]	-3.532	[0.000]
CATALUÑA & MADRID & PAIS VASCO	8	<b>-2.242</b>	<b>[0.012]</b>	<b>-1.599</b>	<b>[0.055]</b>

a Indicates the number of provinces included in each panel.

b The  $t$ -bar statistic, derived by Im-Pesaran-Sin (2003), converges in probability to a standard normal distribution.