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Youth Unemployment in Europe: Persistence and Macroeconomic Determinants

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This paper investigates the statistical features and the macroeconomic determinants of youth unemployment in a number of European countries. First, it explores its short and long memory properties by estimating both autoregressive and fractional integration. This analysis sheds light on the degree of persistence of the series, and on whether policy actions are required for highly persistent series. Second, it investigates the main determinants of youth unemployment in Europe by estimating fractional cointegration models. The evidence suggests that this series is highly persistent in all the countries examined, and that in some of them there is a significant long-run equilibrium relationship linking it to macroeconomic variables such as GDP and inflation.
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INTRODUCTION

Youth unemployment has attracted significant attention in recent years, especially in Europe, where it is particularly high relative to adult unemployment (see, eg, Perugini and Signorelli, 2010), and has been affected even more than the latter by financial crises (see Choudhry *et al.*, 2012). Some key factors driving it that have been identified include the relatively low human capital of young people (see OECD, 2005), the 'youth experience gap' (see Caroleo and Pastore, 2007) and the mismatch between the skills acquired through education and those required by employers (see, eg, Quintini *et al.*, 2007). Policy recommendations have been put forward both in the academic literature (see, eg, Brunello *et al.*, 2007) and by the European Commission (2008).

This paper investigates the main statistical features and the macroeconomic determinants of youth unemployment in a number of European countries. It is well-known that an important feature of unemployment in Europe is its relatively high degree of persistence, which suggests that a hysteresis model (Blanchard and Summers, 1986; Gordon, 1988) might be appropriate. In fact, many empirical papers have found evidence consistent with this hypothesis, including Alogoskoufis and Manning (1988), Graafland (1991), Lopez *et al.* (1996), Wilkinson (1997) and so on using standard unit root methods, and Caporale and Gil-Alana (2008) and Cuestas *et al.* (2011) and others applying fractional integration methods. High persistence appears to be a feature also of European youth unemployment (see, eg, Heckman and Borjas, 1980; Ryan, 2001; Caporale and Gil-Alana, 2013). Therefore, first of all we examine the degree of persistence of the series, which sheds light on whether appropriate policy actions are required in case of high persistence, by estimating both autoregressive AR(1) processes and long memory (fractional integration) models. Second, we investigate the main macroeconomic determinants of youth unemployment in Europe by means of a fractional cointegration model that includes variables such as GDP and inflation as explanatory variables. The organization of the paper is as follows. The next section outlines the econometric framework. The penultimate section presents the data and the empirical results. The final section offers some concluding remarks.

THE ECONOMETRIC FRAMEWORK

As mentioned in the introduction, our main analysis is based on the concept of fractional integration, which allows the differencing parameter d making a series stationary $I(0)$ to be a fraction as well as an integer. Therefore, the series of interest can be represented as

$$(1-L)^d x_t = u_t, \qquad t = 0, \ \pm 1, \ \ldots \tag{1}$$

where u_t is assumed to be an $I(0)$ process, defined as a covariance stationary process with a bounded positive spectral density function. Note that this approach includes the unit root case as a particular case when $d = 1$.

Given the above parameterization, one can consider different cases depending on the value of d. Specifically, if $d=0$ and $x_t=u_t$, x_t is said to be a 'short memory' or $I(0)$ process, and in the case of autocorrelated (AR) disturbances the autocorrelation is 'weak', that is, the autocorrelation function decays at an exponential rate; if $d>0$, x_t is said to be a 'long memory' process, so called because of the strong association between observations far apart in time. In this case, if d belongs to the interval $(0, 0.5)$, x_t is still covariance stationary, while $d \geq 0.5$ implies non-stationarity. Finally, if $d<1$, the series is mean-reverting, with the effects of shocks disappearing in the long run, in contrast to the case with $d \geq 1$ where these persist forever.

Two methods of estimation of the fractional differencing parameter are employed here: one is a Whittle parametric approach in the frequency domain (Dahlhaus, 1989), while the other is a semiparametric 'local' Whittle method (Robinson, 1995; Abadir *et al.*, 2007). In addition, a simple AR(1) model is also considered as an alternative to measure persistence as the autoregressive coefficient. Other more general AR(p) processes could be considered, with persistence than being defined as the sum of the AR coefficients. However, given the relatively small sample size in our case, a simple AR(1) specification is adequate to describe the short-run dynamics of the series.

The fractional integration framework can be extended to the multivariate case by estimating a fractional cointegration model. Specifically, we follow the approach developed in Gil-Alana (2003), which is a natural generalization of Engle and Granger's (1987) procedure allowing for fractional parameters. In particular, we estimate a linear regression of youth unemployment against its macroeconomic determinants and check the significance of the estimated coefficients as well as the order of integration of the residuals; if this is smaller than for the individual series, then cointegration holds and there exists a long-run equilibrium relationship between the variables that can be interpreted as the steady state in economic terms. In addition, a Hausman test for the null of no cointegration against the alternative of fractional cointegration, as suggested by Marinucci and Robinson (2001), is also carried out.

EMPIRICAL RESULTS

The data used include the total youth unemployment rate in 15 countries, Austria, Belgium, Denmark, Finland, France, Greece, Ireland, Italy, Luxembourg, the Netherlands, Norway, Portugal, Spain, Sweden and the United Kingdom. This variable is defined as the number of unemployed in the 15–24 years age group divided by the labor force for that group, obtained from the International Labor Organisation. For GDP, inflation, output and consumer prices, data from the World Development Indicators are used. All series are annual and span the period from 1980 to 2005.

As a preliminary step we estimate a simple AR(1) process to measure the persistence of the series as its AR(1) coefficient. The results for the three series are displayed in Table 1.

It can be seen that the autoregressive coefficients are much higher for youth unemployment and inflation compared with GDP. In the case of youth unemployment, the highest values are found for the peripheral (Northern and Southern) countries: Ireland (0.94), Finland (0.92), the Netherlands (0.89), Spain (0.89), Norway (0.88), Sweden (0.88), Italy (0.87) and Greece (0.86). This high level of persistence is consistent with the empirical evidence on total unemployment in most European countries, suggesting the relevance of hysteresis models in the European case (see, eg, Gordon, 1989; Graafland, 1991; Lopez *et al.*, 1996).

Next, we estimate the fractional differencing parameter d and the corresponding 95% intervals for each of the three series, youth unemployment, inflation and GDP, in each country using the parametric approach based on the Whittle function in the frequency domain. In all cases, an intercept is included in the model and the d-differenced process is assumed to be a white noise process. We report in bold in Table 2 the cases where the unit root null hypothesis, $d=1$, cannot be rejected.

This happens in five countries, the United Kingdom, Italy, Norway, Sweden and Ireland, for all three series. In the case of youth unemployment, rejections of the null hypothesis in favor of higher degrees of integration only occur for Finland, the Netherlands, Portugal and Spain, the latter two countries

Table 1: Estimated AR coefficients for each series in each country

Country	Youth unemployment	Inflation	GDP
The United Kingdom	0.838	0.683	0.586
Italy	0.872	0.978	0.443
Austria	0.848	0.607	0.194
Belgium	0.715	0.765	0.061
Denmark	0.605	0.876	0.173
Finland	0.925	0.935	0.608
France	0.763	0.969	0.345
Greece	0.866	0.937	0.488
Ireland	0.940	0.764	0.567
Luxembourg	0.795	0.697	0.112
The Netherlands	0.893	0.791	0.648
Norway	0.888	0.908	0.487
Portugal	0.839	0.929	0.639
Spain	0.892	0.963	0.626
Sweden	0.885	0.849	0.434

Table 2: Estimates of d and 95% confidence intervals for the individual series

Country	Youth unemployment	Inflation	GDP
The United Kingdom	**1.37 (0.31, 2.10)**	**0.53 (0.31, 1.35)**	**0.72 (0.02, 1.61)**
Italy	**1.15 (0.94, 1.45)**	**1.43 (0.47, 1.83)**	**0.29 (−0.07, 1.10)**
Austria	**1.09 (0.71, 1.50)**	**0.44 (0.12, 1.02)**	0.08 (−0.30, 0.57)
Belgium	**0.81 (0.31, 1.31)**	**0.97 (0.01, 1.54)**	−0.15 (−0.62, 0.39)
Denmark	**0.59 (0.27, 1.35)**	**0.25 (−0.08, 1.12)**	0.05 (−0.34, 0.55)
Finland	1.96 (1.31, 2.72)	**1.02 (0.49, 1.58)**	**0.72 (0.19, 1.46)**
France	**1.09 (0.44, 1.61)**	**1.33 (1.00, 1.67)**	0.23 (−0.24, 0.80)
Greece	**1.01 (0.42, 1.52)**	**0.72 (0.55, 1.27)**	0.26 (0.04, 0.53)
Ireland	**1.29 (0.92, 1.84)**	**0.97 (0.10, 1.47)**	**0.47 (0.24, 1.05)**
Luxembourg	**1.16 (0.28, 1.76)**	**1.26 (−0.14, 1.88)**	0.05 (−0.34, 0.47)
The Netherlands	1.76 (1.31, 2.25)	**1.08 (0.42, 1.60)**	**0.91 (0.42, 1.68)**
Norway	**1.41 (0.78, 2.16)**	**0.72 (0.49, 1.29)**	**0.41 (−0.11, 1.84)**
Portugal	1.69 (1.10, 2.32)	**1.31 (0.77, 2.14)**	**0.81 (0.24, 1.46)**
Spain	1.62 (1.19, 2.14)	**0.99 (0.65, 1.37)**	**0.78 (0.34, 1.37)**
Sweden	**1.33 (0.91, 1.92)**	**0.51 (0.33, 1.06)**	**0.33 (−0.04, 1.04)**

Note: In bold, evidence of unit roots ($d = 1$) at the 5% level.

having some of the highest youth unemployment rates in the sample. For inflation, the unit root null cannot be rejected in any case. For GDP, this hypothesis is rejected in favor of explosive behavior (d>1) in Finland, the Netherlands, Portugal and Spain, evidence of mean-reversion (d<1) is found for Austria, Belgium, Denmark, France, Greece and Luxembourg.

Table 3 focuses on the semiparametric results using three different bandwidth parameters. For each series there is at least one case when the unit root null hypothesis cannot be rejected. Given the evidence of non-stationarity, the estimation was carried out using first differences, then adding 1 to the estimated values to obtain the integration orders. Overall, this evidence suggests non-stationarity and the presence of a unit root in all three series in all countries examined.

The step is the estimation of a multivariate cointegration model. We started by including the same set of variables as in previous studies by Jacobsen (1999), Blanchflower and Freeman (2000), Choudhry *et al.* (2012). In particular, there is a large literature emphasizing the impact of output and its growth on unemployment, the so-called Okun's law (see, eg, Lee, 2000; Solow, 2000). Moreover, it appears that youth unemployment is even more sensitive to macroeconomic and labor market conditions than is total unemployment (see Choudhry *et al.*, 2013). However, since regressors such as FDI and openness were found not to be significant, the results reported below are those obtained from a model including GDP and inflation only as the

Table 3: Estimates of d based on a local Whittle semiparametric method

Country	Youth unemployment			Inflation			GDP		
	4	5	6	4	5	6	4	5	6
UK	**0.701**	**1.169**	1.453	**0.762**	**1.004**	**0.770**	**0.733**	**0.889**	**1.166**
Italy	**1.386**	1,500	1.363	1.423	1.500	1.500	**1.137**	0.511	0.572
Austria	**0.932**	**0.965**	**1.220**	**1.078**	**0.669**	0.645	0.500	0.521	**0.668**
Belgium	**0.926**	**0.955**	**1.171**	**0.719**	**0.925**	**1.052**	**0.588**	**0.664**	0.563
Denmark	**0.901**	**1.208**	**0.806**	**0.899**	**0.881**	**1.077**	**0.598**	0.534	**0.710**
Finland	**1.095**	1.388	1.500	**0.838**	**1.198**	**1.084**	0.500	**0.782**	**1.008**
France	**1.408**	**1.149**	1.393	**1.220**	1.500	1.500	0.500	**0.882**	0.524
Greece	0.500	0.605	**0.878**	0.500	0.517	**0.730**	0.500	**0.701**	0.500
Ireland	**1.174**	**1.335**	1.500	1.500	1.455	**1.194**	**0.725**	**0.958**	0.569
Luxembourg	**1.163**	**1.294**	**1.261**	**0.915**	**1.131**	**1.256**	0.500	**0.934**	**1.100**
The Netherlands	**1.222**	1.500	1.500	1.430	1.500	**1.178**	**0.664**	**0.682**	**0.928**
Norway	0.582	**0.655**	**0.996**	0.500	**0.774**	**0.785**	0.505	0.500	**0.788**
Portugal	**0.592**	**1.159**	1.455	**0.678**	**0.907**	**1.141**	**0.765**	**0.994**	**1.238**
Spain	0.507	**1.189**	1.500	1.487	**1.019**	**1.188**	0.500	**0.999**	**0.864**
Sweden	**0.637**	**1.199**	1.421	**0.748**	**0.802**	**0.777**	**0.612**	**0.641**	0.507
Lower I(1) interval	0.588	0.632	0.664	0.588	0.632	0.664	0.588	0.632	0.664
Upper I(1) interval	1.411	1.367	1.335	1.411	1.367	1.335	1.411	1.367	1.335

Note: In bold, estimated value of d in the cases when cointegration holds.

Table 4: Parameter estimates in the cointegrating relationship with uncorrelated errors

	d	α	β_1	β_2
The United Kingdom	1.25 (0.47, 1.89)	**23.233 (27.93)**	**−0.610 (−4.44)**	−0.018 (−0.16)
Italy	0.89 (0.73, 1.19)	**32.965 (9.04)**	**−0.434 (−2.64)**	**−0.452 (−2.08)**
Austria	1.09 (0.71, 1.52)	**5.285 (3.68)**	−0.026 (−0.14)	0.013 (0.09)
Belgium	0.81 (0.29, 1.31)	**23.813 (5.76)**	−0.056 (−0.12)	−0.042 (−0.11)
Denmark	0.89 (0.16, 1.46)	**14.436 (3.71)**	**−0.738 (−1.43)**	**−0.707 (−3.13)**
Finland	1.98 (1.28, 2.91)	**9.732 (2.45)**	−0.263 (−0.80)	0.227 (1.51)
France	0.91 (0.43, 1.55)	**25.247 (4.86)**	**−0.702 (−1.99)**	−0.249 (−0.74)
Greece	0.91 (0.54, 1.38)	**23.435 (6.32)**	**−0.358 (−2.55)**	−0.069 (−0.38)
Ireland	1.08 (0.82, 1.81)	**26.755 (7.42)**	**−0.649 (−2.29)**	**−0.330 (−2.36)**
Luxembourg	0.15 (0.18, 1.80)	**7.926 (2.14)**	−0.093 (−0.28)	−0.058 (−0.52)
The Netherlands	1.78 (1.30, 2.30)	**10.004 (3.20)**	−0.496 (−1.42)	0.243 (0.82)
Norway	1.34 (0.59, 2.16)	**9.742 (4.04)**	**−0.410 (−2.62)**	−0.194 (−1.38)
Portugal	2.02 (1.29, 2.90)	**21.066 (9.50)**	**−0.159 (−1.74)**	**−0.358 (−3.10)**
Spain	1.63 (1.14, 2.18)	**35.311 (5.12)**	**−0.664 (−1.66)**	**−0.603 (−1.75)**
Sweden	1.29 (0.82, 2,03)	**10.011 (2.31)**	−0.239 (−1.02)	**−0.353 (−1.73)**

Note: In bold, significant coefficients at the 5% level.

macroeconomic determinants of youth unemployment, namely

$$y_t = \alpha + \beta x_{1t} + x_{2t} + x_t; \qquad (1-L)^d x_t = u_t, \quad t = 1, 2, \ldots \tag{2}$$

where y_t stands for the youth unemployment rate, x_{1t} for inflation and x_{2t} for

Table 5: Parameter estimates in the cointegrating relationship with autocorrelated errors

	d	α	β_1	β_2	AR
UK	0.11 (−0.24, 0.38)	**44.244 (42.89)**	**−0.174 (−1.88)**	0.319 (1.49)	0.742
Italy	0.02 (−0.26, 0.43)	**−54.025 (−64.11)**	**−0.143 (−1.80)**	**1.496 (4.69)**	0.810
Austria	−0.07 (−0.37, 0.29)	**42.765 (35.134)**	**−0.413 (−1.85)**	**−0.516 (−1.96)**	0.895
Belgium	0.01 (−0.36, 0.33)	**65.367 (4.17)**	**−0.612 (−1.82)**	0.014 (0.03)	0.664
Denmark	0.07 (−0.36, 0.29)	**34.287 (32709)**	**−0.984 (−3.75)**	**−0.299 (−1.97)**	0.655
Finland	0.58 (0.14, 0.89)	**28.789 (8.74)**	**−1.272 (−4.26)**	−0.015 (−0.07)	0.710
France	0.10 (−0.29, 0.47)	**7.693 (6.74)**	**−0.551 (−4.50)**	−0.312 (−0.85)	0.744
Greece	0.01 (−0.37, 0.39)	**−254.69 (−167.89)**	**−0.387 (−4.71)**	−0.077 (−0.28)	0.863
Ireland	0.04 (−0.34, 0.45)	**122.00 (50.82)**	**−0.723 (−2.04)**	**−1.220 (−4.98)**	0.708
Luxembourg	−0.04 (−0.57, 0.18)	**43.189 (30.14)**	**−0.370 (−2.28)**	**−0.470 (−2.39)**	0.499
The Netherlands	0.14 (−0.23, 0.37)	**39.544 (18.41)**	**−0.516 (−1.94)**	−0.134 (−0.28)	0.735
Norway	0.05 (−0.28, 0.39)	**22.147 (35.38)**	**−0.665 (−9.68)**	**−0.258 (−1.88)**	0.712
Portugal	0.21 (−0.07, 0.44)	**1.772 (1.41)**	**−0145 (−1.99)**	**−0.214 (−1.85)**	0.792
Spain	0.16 (−0.14, 0.47)	**−1.679 (−0.46)**	0.081 (−0.27)	−0.649 (−0.96)	0.931
Sweden	−0.11 (−0.22, 0.41)	**15.842 (12.34)**	**−1.196 (−8.26)**	**−1.060 (−2.90)**	0.736

Note: In bold, significant coefficients at the 5% level.

GDP. The error term u_t is assumed to be a white noise or have an autocorrelated structure in Tables 4 and 5, respectively.

Table 4 shows that for six countries, Italy, Belgium, Denmark, France, Greece and Luxembourg, the estimated value of d is smaller than 1; however, in all these cases the confidence intervals are so wide that the unit root null hypothesis cannot be rejected. In fact, the only rejections of the unit root null occur in the cases of Finland, the Netherlands, Portugal and Spain, but always in favor of higher orders of integration.[1] Therefore, there is no evidence of cointegration of any degree under the assumption of uncorrelated errors. As for the estimated coefficients, they are all negative and more significant for inflation than GDP.

Next, we analyze the case with autocorrelated disturbances. Specifically, we consider a simple AR(1) process, the reason being that, given the small number of observations, higher orders would lead to overparameterized models. In this case all the estimated values of d are below 1 and close to 0 in many cases, implying mean-reversion and therefore cointegration. The low fractional differencing parameter is now combined with a very large AR coefficient, implying that the errors are still very persistent. Only for Finland is d significantly above 0. As for the estimated coefficients, the inflation coefficient is significant and negative in all countries except Spain, while the GDP coefficient is significant in half of the cases. Given the differences in the

[1] These countries also display orders of integration above 1 in the univariate analysis.

results depending on the specification of the error term, we also estimated d in equation (2) using a log-periodogram semiparametric estimator. These additional results, not reported, suggest that the differencing parameter is very sensitive to the bandwidth parameter, although most cases lie in the interval between 0.5 and 1, implying fractional integration, non-stationarity and mean-reverting behavior.

Finally, we perform the Hausman test proposed by Marinucci and Robinson (2001). This is specified as follows:

$$H_{is} = 8s\left(\hat{d}^{*} - \hat{d}_{i}\right)^{2} \rightarrow d\chi_{1}^{2} \qquad \text{as} \quad \frac{1}{s} + \frac{s}{T} \rightarrow 0 \tag{3}$$

where $i = x$, y and z stand for each of the series under examination, youth unemployment, inflation and GDP, in turn, s is the bandwidth parameter (we set $s = (T)^{0.5}$), $\hat{d}_i$ are the univariate estimates of the parent series and $\hat{d}^{*}$ is a restricted estimate obtained in the multivariate representation

Table 6: Testing the null of no cointegration with the Hausman test of Marinucci and Robinson (2001)

The United Kingdom	Italy	Austria
$H_{xs} = 11.449$[a]	$H_{xs} = 23.104$[a]	$H_{xs} = 0.025$
$H_{xs} = 5.475$[a]	$H_{xs} = 28.696$[a]	$H_{xs} = 0.585$
$H_{xs} = 2.601$	$H_{xs} = 0.064$	$H_{xs} = 2.140$
$\boldsymbol{d} = \mathbf{0.634}$	$\boldsymbol{d} = \mathbf{0.576}$	$d = 0.957$
Belgium	Denmark	Finland
$H_{xs} = 0.625$	$H_{xs} = 3.387$	$H_{xs} = 0.064$
$H_{xs} = 0.361$	$H_{xs} = 0.051$	$H_{xs} = 0.392$
$H_{xs} = 1.102$	$H_{xs} = 1.714$	$H_{xs} = 0.331$
$d = 0.830$	$d = 0.917$	$d = 1.099$
France	Greece	Ireland
$H_{xs} = 0.134$	$H_{xs} = 0.784$	$H_{xs} = 12.678$[a]
$H_{xs} = 0.665$	$H_{xs} = 3.317$	$H_{xs} = 7.7157$[a]
$H_{xs} = 0.275$	$H_{xs} = 3.019$	$H_{xs} = 1.398$
$d = 1.091$	$d = 1.018$	$\boldsymbol{d} = \mathbf{0.771}$
Luxembourg	The Netherlands	Norway
$H_{xs} = 16.796$[a]	$H_{xs} = 9.063$[a]	$H_{xs} = 0.108$
$H_{xs} = 9.409$[a]	$H_{xs} = 7.464$[a]	$H_{xs} = 2.766$
$H_{xs} = 3.317$	$H_{xs} = 1.324$	$H_{xs} = 2.704$
$\boldsymbol{d} = \mathbf{0.646}$	$\boldsymbol{d} = \mathbf{0.746}$	$d = 1.048$
Portugal	Spain	Sweden
$H_{xs} = 13.548$[a]	$H_{xs} = 0.0144$	$H_{xs} = 12.144$[a]
$H_{xs} = 4.355$[a]	$H_{xs} = 3.193$	$H_{xs} = 14.161$[a]
$H_{xs} = 6.955$[a]	$H_{xs} = 1.747$	$H_{xs} = 12.144$[a]
$\boldsymbol{d} = \mathbf{0.577}$	$d = 1.208$	$\boldsymbol{d} = \mathbf{0.816}$

Note: In bold, estimated value of d in the cases when cointegration holds.
[a]Statistical evidence of cointegration at the 5% level.

under the assumption that $d_x = d_y = d_z$. The results using this approach are displayed in Table 6.

The test statistics indicate the presence of fractional cointegration in seven out of the fifteen countries examined, with statistical significance for youth unemployment and inflation in the majority of cases. It is also noteworthy that the estimated order of integration in the cointegrating regression is in the interval (0.5, 1) in all cases, implying non-stationary mean-reverting behavior. The highest degree of cointegration is found in the case of Italy and Portugal, where the estimated d is equal to 0.576 and 0.577, respectively, followed by the United Kingdom (0.634), Luxembourg (0.646), the Netherlands (0.746), Ireland (0.771) and Sweden (0.810). For the remaining countries, this approach provides no evidence of cointegration.

CONCLUSIONS

Both academics and policymakers have recently focused on the challenge represented by European youth unemployment, which has become even higher relative to adult unemployment following the recent financial crisis and appears to be very persistent. This paper has investigated its stochastic properties as well as its macroeconomic determinants by using annual data on total youth unemployment in 15 countries and estimating autoregressive and long memory (fractionally integrated) models as well as fractional cointegration ones. The evidence confirms that youth unemployment is highly persistent in all European countries examined, which suggests the relevance of hysteresis models (Blanchard and Summers, 1986; Gordon, 1988) in a European context and the need for active labor market policies aimed at preventing short-term unemployment from becoming structural or long term. These could include better school-to-work transition institutions as well as educational, placement and training schemes (see Choudhry *et al.*, 2012).

As for the macroeconomic factors driving European youth unemployment, the fractional cointegration results are rather sensitive to the method applied. Specifically, when following the approach of Gil-Alana (2003), the findings are different depending on the underlying assumptions about the error term: if the errors are assumed to be uncorrelated, no evidence of cointegration is found in any case; by contrast, under the assumption of autocorrelated errors, cointegration appears to hold in all cases. When using the semiparametric method of Marinucci and Robinson (2001) some evidence of (fractional) cointegration is obtained in some cases with its estimated order in the interval (0.5, 1). A plausible explanation for the sensitivity of the results to the method employed is the relatively small size of the sample used.

Nevertheless, the analysis provides some useful evidence on the existence of long-run relationships between youth unemployment in Europe and two key macroeconomic determinants, GDP and inflation. It confirms in particular the importance of the linkage between output and unemployment and the sensitivity of youth unemployment to overall macroeconomic conditions (see Choudhry *et al.*, 2013). Of course, a key role is also played by macroeconomic and labor market policies and institutions, as, for instance, stressed by the OECD (2006), but recommending the specific actions required to address the so-called 'Euro-sclerosis' or poor employment performance of most European countries is an issue beyond the scope of the present study, whose aim is simply to offer some evidence on the persistence of youth unemployment in Europe and its relationship to output and inflation.

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REFERENCES

Abadir, KM, Distaso, W and Giraitis, L. 2007: Nonstationarity-extended local whittle estimation. *Journal of Econometrics* 141: 1353–1384.

Alogoskoufis, GS and Manning, A. 1988: On the persistence of unemployment. *Economic Policy* 7: 427–469.

Blanchard, OJ and Summers, LH. 1986: Hysteresis and the European unemployment problem. *NBER Macroeconomics Annual* 1: 15–78.

Blanchflower, DG and Freeman, R. 2000: *Youth unemployment and joblessness*. University of Chicago Press: Chicago, IL.

Brunello, G, Garibaldi, P and Wasmer, E. 2007: *Education and training in Europe*. Oxford University Press: New York, NY.

Caporale, GM and Gil-Alana, LA. 2008: Modelling the US, UK and Japanese unemployment rates: Fractional integration and structural breaks. *Computational Statistics and Data Analysis* 52(11): 4998–5013.

Caporale, GM and Gil-Alana, LA. 2013: Persistence in youth unemployment. *Empirical Economics Letters* 12(3): 319–325.

Caroleo, FE and Pastore, F. 2007: *The Youth Experience Gap: Explaining Differences Across EU Countries*. Quaderni del Dipartimento di Economia, Finanza e Statistica 41, University of Perugia: Perugia, Italy.

Choudhry, MT, Marelli, E and Signorelli, M. 2012: Youth unemployment rate and impact of financial crises. *International Journal of Manpower* 33(1): 76–95.
Choudhry, MT, Marelli, E and Signorelli, M. 2013: Youth and total unemployment rate: The impact of policies and institutions. *Rivista Internazionale di Scienze Sociali* 1: 63–86.
Cuestas, JC, Gil-Alana, LA and Staehr, K. 2011: A further investigation of the unemployment persistence in European transition economies. *Journal of Comparative Economics* 39: 514–532.
Dahlhaus, R. 1989: Efficient parameter estimation for self-similar process. *Annals of Statistics* 17: 1749–1766.
Engle, RF and Granger, CWJ. 1987: Cointegration and error correction: Representation, estimation, and testing. *Econometrica* 55: 251–276.
European Commission. 2008: *Employment in Europe*. Ch. 5. European Commission: Luxembourg.
Gil-Alana, LA. 2003: Testing of fractional cointegration in macroeconomic time series. *Oxford Bulletin of Economics and Statistics* 65(4): 517–529.
Gordon, RJ. 1988: Back to the future. European unemployment today viewed from America in 1939. *Brooking Papers on Economic Activity* 19: 1271–1232.
Gordon, RJ. 1989: Hysteresis in history. Was there ever a Phillips curve? American economic review. *Papers and Proceedings* 79: 220–225.
Graafland, JJ. 1991: On the causes of hysteresis in long term unemployment in the Netherlands. *Oxford Bulletin of Economics and Statistics* 53(2): 155–170.
Heckman, JJ and Borjas, GJ. 1980: Does unemployment cause future unemployment? Definitions, questions and answers from a continuous time model of heterogeneity and state dependence. *Economica* 47(187): 247–283.
Jacobsen, JP. 1999: Labor force participation. *Quarterly Review of Economics and Finance* 39(5): 597–610.
Lee, J. 2000: The robustness of Okun's law: Evidence from OECD countries. *Journal of Macroeconomics* 22(2): 331–356.
Lopez, H, Ortega, E and Ubide, A. 1996: *Explaining the dynamics of Spanish unemployment*. Working Paper in Economics. no. 96/14, European University Institute, Florence, Italy.
Marinucci, D and Robinson, PM. 2001: Semiparametric fractional cointegration analysis. *Journal of Econometrics* 105: 225–247.
OECD. 2005: *Education at Glance*. OECD: Paris.
OECD. 2006: *Employment Outlook*. OECD: Paris.
Perugini, C and Signorelli, M. 2010: Youth labour market performance in European regions. *Economic Change and Restructuring* 43(2): 151–185.
Quintini, G, Martin, JP and Marti, S. 2007: *The changing nature of the school-to-work transition process in OECD countries*. DP no. 2582. Institute for Study of Labor, IZA: Bonn.
Robinson, PM. 1995: Gaussian semi-parametric estimation of long range dependence. *Annals of Statistics* 23: 1630–1661.
Ryan, P. 2001: The school-to-work transition: A cross-national perspective. *Journal of Economic Literature* 39(1): 34–92.
Solow, RM. 2000: *Who is hit hardest during a financial crisis? The vulnerability of young men and women to unemployment in an economic downturn*. IZA Discussion Papers 4359, IZA: Bonn.
Wilkinson, G. 1997: *A micro approach to the issue of hysteresis in unemployment; evidence from the 1988–1990 labour market activity survey*. Bank of Canada, Working Papers 97–12.