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Unemployment hysteresis, structural changes, non-linearities and fractional integration in European transition economies

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Abstract

In this paper we aim to analyse the dynamics of unemployment in a group of Central and Eastern European Countries (CEECs). The CEECs are of special importance for the future of the European Union, given that most of them have recently become member states, and labour flows have been seen to rise with their accession. By means of unit root tests incorporating structural changes and nonlinearities, as well as fractional integration, we find that the unemployment rates for the CEECs are mean reverting processes, which is consistent with the NAIRU hypothesis, although shocks tend to be highly persistent.

J.E.L. Classification : C32, E24
Key words: Unemployment, NAIRU, hysteresis, unit roots, fractional integration

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1. Introduction

Analysis of the dynamic statistical properties of unemployment rates has, in recent decades, become a popular topic within the applied macroeconomics literature. Within this literature four main theories have been formulated in order to explain why unemployment behaves in a particular way. First, the NAIRU (Non-accelerating inflation rate of unemployment) establishes that shocks only have transitory effects and there exists a long run unemployment rate. Second, the structuralist view point, states that changes in fundamentals may shift the equilibrium unemployment rate over time, which is a more relaxed version of the NAIRU theory. Given, the high unemployment rate seen in European countries in recent decades, two more theories have arisen; the persistence hypothesis explains unemployment as a variable that needs long periods to recover after a shock, whereas the *hysteresis* hypothesis implies that unemployment can be characterised as a random walk, which never reverts to an equilibrium after a shock. If unemployment is characterised as a unit root process (*hysteresis)*, macroeconomic policy measures should be focussed on structural reforms in order to counter a negative shock. On the other hand, should unemployment be a stationary process (NAIRU), macroeconomic policy should focus on the prevention of short run departures from the equilibrium (see Section 2 for more detail).

The dynamic properties of unemployment rates have been widely discussed for industrialised countries, with particular attention given to Western Europe and the US. The reason is, at least, twofold. First, high unemployment rates have not only economic, but also political and social consequences (Layard et al., 2005). Second, although European unemployment rates traditionally have been high and persistent, the recent 2008-2009 economic crisis has pushed unemployment rates even higher. This situation casts doubts about the empirical fulfilment of the natural rate of unemployment (NAIRU).

In this paper we analyse unemployment rates for a pool of Central and Eastern European countries (CEECs). This group of countries was in transition from communism to market economies until at least the late 1990s. The transition process impacted on their economic structures and on the paths of their unemployment rates. Unemployment in these countries first jumped as a consequence of the rapid labour market reforms during the transition process. Subsequently, the creation of new jobs in the private sector was slow compared with the job destruction (Boeri and Terrell, 2002). Hence, a significant proportion of total unemployment is structural in character (León-Ledesma and McAdam, 2004).

Whilst EU unemployment is far from being considered low in 2009, future developments in labour markets in the enlarged EU may also define new trends in labour movements. Potentially high unemployment rates in the CEECs may have important effects on the migratory flows of labour force between the new and old EU member states. In addition, within the context of economic integration, unemployment is one of the key variables facilitating the adjustment process through macroeconomic equilibrium. In this paper we are going to focus on the period 1998-2007, a period after the initial transition shock, through to the first years of EU accession. The Accession Criteria from the 1993 Copenhagen Summit established the following three aspects that countries need to fullfil in order to join the EU,

1. Political: stability of institutions guaranteeing democracy, the rule of law, human rights, and respect for and protection of minorities;
2. Economic: the existence of a functioning market economy as well as the capacity to cope with competitive pressure and market forces within the Union;
3. Institutional: the ability to take on the obligations of membership including adherence to the aims of political, economic and monetary union.

The existence of a functioning market economy implies, among other things, that macroeconomic stability has been achieved. At the 1997 Luxembourg Summit, Accession Partnerships were agreed, and set up with each applicant in March 1998, to assist in getting the entire economy ready for EU membership. Hence, 1997 marked a fundamental turning point in the process of transition, moving into preparing for EU accession. The macroeconomic stabilisation measures that these countries had to accomplish in order to meet the requirements for joining the EU may have caused significant shocks to output, prices and unemployment (Cuestas and Ordóñez, 2009; and Cuestas and Harrison, 2010). Hence the choice of this timeframe for our analysis (see section 5).

In this paper we test for the order of integration of CEECs' unemployment rates (Czech Republic, Estonia, Hungary, Latvia, Lithuania, Poland, Romania, Slovak Republic and Slovenia) in order to gain insights into the recent developments of this variable. We apply a battery of unit root tests that take into account the possibility of non-linearity in the long run path of the variable. Non-linearities may be present as an asymmetric speed of adjustment towards the equilibrium, e.g., the autoregressive parameter may differ depending on the values of the variable, and in the form of structural changes in the deterministic components. Bearing in mind that these two types of non-linearities have been recognised as sources of power problems in traditional (linear) unit root tests (see Kapetanios et al, (KSS, 2003), and Perron, 1989, among many others), we apply the Lee and Strazicich (LS, 2003) unit root test which considers the possibility of structural changes; the KSS test which accounts for the possibility of an asymmetric speed of adjustment towards the equilibrium; the Kruse (2010) test, which is an extension of the KSS test; and the Bec, Ben Salem and Carrasco (BBC, 2004) unit root test which considers a three-regime self-exciting threshold autoregressive (SETAR) model.

The aforementioned unit root tests only consider integer numbers for the order of integration, say *d*, which may be too restrictive. Following recent contributions in the field of spectral analysis, long memory and fractional integration, we also apply a version of the tests of Robinson (1994), which take into account the possibility of values of d in the interval (0, 1) or even above 1. Fractionally integrated (or *I(d)*) models can be specified as

$$(1 - L)^d x_t = u_t, \qquad t = 1, \dots, T, \tag{1}$$

where u_t is a covariance stationary *I(0)* process, whose spectral density function is positive and finite at the zero frequency, *d* can be any real number, and *L* is the lag operator. We can re-write the above equation as

$$(1 - L)^d x_t = x_t - d x_{t-1} + \frac{d(d-1)}{2} x_{t-2} - \frac{d(d-1)(d-2)}{6} x_{t-3} + \dots \tag{2}$$

provided that

$$(1 - L)^d = \sum_{j=0}^{\infty} \binom{d}{j} (-1)^j L^j. \tag{3}$$

Therefore, the closer is the parameter *d* to 1, the more persistent the process is, and the effect of shocks on the variable will last longer. If $d \in (0, 0.5)$ the series is covariance stationary and mean reverting. However, if $d \in [0.5, 1)$ the series is no longer stationary but still mean reverting. The case when $d \geq 1$ implies that the series is non-stationary and non-mean reverting. The fact that u_t in (1) is I(0) allows for the possibility of weak autocorrelation of the *ARMA(p, q)* form. In such a case, the process is said to be autoregressive, fractionally integrated, moving average *ARFIMA(p, d, q)* of the form

$$\Phi_p(L)(1-L)^d x_t = \Theta_q(L)\varepsilon_t, \quad t = 1,...T, \tag{4}$$

where $\Phi_p(L)$ and $\Theta_q(L)$ are polynomials of orders p and q respectively, with all zeros of $\Phi_p(L)$ outside the unit circle, and all zeros of $\Theta_q(L)$ outside or on the unit circle, and ε_t a white noise process (Granger and Joyeux, 1980; Granger, 1980, 1981; Hosking, 1981).

Whether unemployment is stationary and mean reverting, non-stationary and mean reverting or non-stationary and non-mean reverting, will give us insights about the degree of persistence of the unemployment rates in our targeted CEECs (see Table 1).

The rest of the paper is organised as follows. The next section briefly sets out economic theories about the dynamics of unemployment. Section 3 summarises recent contributions on the order of integration of unemployment using time series techniques. In section 4 we present the methodology employed in the paper. Section 5 summarises the results from applying the unit root and fractional integration tests in the unemployment rate series; finally, the last section concludes the paper.

2. Unemployment hypotheses

From a theoretical viewpoint, the first hypothesis regarding the dynamic behaviour of unemployment is the NAIRU hypothesis. Accordingly, there is a unique long run equilibrium for unemployment rates and, therefore, the Phillips Curve is vertical, i.e. there is no trade-off between inflation and output in the long run. However, in the short run there may be transitory deviations from the long run equilibrium. This implies that the variable is a stationary and mean reverting process, where shocks only have transitory effects. Hence, the NAIRU hypothesis implies that d belongs to the interval [0, 0.5), with shocks disappearing fairly rapid.

The reality of recent decades, however, casts doubts on the empirical validity of the NAIRU hypothesis, at least for European countries. In connection with this, a less restrictive version of the NAIRU theory is the one followed by structuralists, who believe that changes in the underlying fundamentals may affect the NAIRU permanently, i.e. result in structural changes and a shift from one equilibrium to another. Phelps (1994), in his book, proposes some theoretical models to explain changes in the natural rate of unemployment, which are due to changes in economic fundamentals, i.e. interest rates, expenditure, capital, productivity, etc.

These models use not only macro, but also micro fundations to explain shifts in unemployment rates (see also Layard et al., 2005, for a summary of these models). The structuralist theory implies that unemployment rates should be an *I(0)* process (or *I(d)* with $d < 0.5$) around a changing or time varying equilibrium value (Papell et al. 2000). Under this theory, the empirical analysis should be done by means of unit root tests that account for the possibility of structural changes. Otherwise, traditional unit root tests may fail to reject the null hypothesis in the presence of structural breaks in the deterministic components.

Current unemployment rates, by appearing to indicate non-stationary, or even explosive, processes, suggest the NAIRU hypothesis may not be an appropriate theoretical starting point. In contrast, the *hysteresis* hypothesis (Blanchard and Summers, 1986, 1987 and Barro, 1988) appears to offer more promising avenues for investigation. According to this hypothesis, shocks to unemployment will never die out, and the variable will never come back to its equilibrium value. This is a characteristic of unit root or explosive processes. There are a number of explanations for this behaviour, including the existence of powerful unions, soft protection schemes, excessively high real wages and the social stigma of the long run unemployed, the latter being particularly important for the CEECs (Phelps, 1972; Blanchard and Summers, 1986, 1987; Clark, 2003 and Layard et al., 2005, amongst others). Also, Cross (1995) explains that *hysteresis* is a non-linear phenomenon, explained mainly by the existence of heterogeneous agents[1]. That said, unemployment could eventually revert to equilibrium after a long period of time. This is a feature of nonstationary long memory processes, $d \in [0.5, 1)$ (see Table 1).

In this paper we confront this theoretical ambiguity over the most appropriate theoretical explanation for unemployment dynamics in the CEECs, by means of unit roots and fractional integration tests. These tests, which will be explained in detail in Section 4, can provide evidentiary support for one or other theory of unemployment dynamics, by focusing on their underlying properties.

3. Brief literature review

Testing for unit roots in unemployment rates has traditionally been an appealing way to test for the empirical fulfilment of unemployment theories. Early studies applied the Augmented Dickey-Fuller (Dickey and Fuller, ADF, 1979) and Phillips-Perron (Phillips and Perron, PP, 1988) unit

[1] See also Faria and León-Ledesma (2008) for a theoretical model, which explains unemployment as a non-linear process with multiple equilibria.

root tests in order to analyse the order of integration of unemployment rates. Thus, Blanchard and Summers (1986), Mitchell (1993), Brunello (1990), Nelson and Plosser (1982) and Roed (1996), find in general that European unemployment contains a unit root, whereas the results for the US are more ambiguous.

However, the above mentioned unit root tests may suffer from power problems when there are structural breaks in the data generation process (DGP). In this case, these tests may incorrectly conclude that unemployment is integrated of order *I(1)*, when in fact it is stationary around a broken or shifting drift (see Perron, 1989). Examples of papers that applied unit root tests with structural breaks to unemployment rate series are Mitchell (1993), Bianchi and Zoega (1998), Arestis and Mariscal (1999), Papell et al. (2000), Ewing and Wunnava (2001), and Chien-Chiang and Chun-Ping (2008) who, in general, found evidence in favour of the structuralist view of unemployment dynamics.

Another series of papers analyse the order of integration of unemployment rates by means of unit root tests for panel data, in order to take into account cross-sectional information. Thus Song and Wu (1997, 1998) and León-Ledesma (2002) find that the *hysteresis* hypothesis is supported by EU data, whereas the NAIRU theory is more appropriate to characterise US unemployment. On the other hand, Christopoulos and León-Ledesma (2007) find evidence against the *hysteresis* hypothesis for EU data. However, the issue of structural breaks is not considered by these authors. Other authors who do apply panel unit root tests with structural breaks (Murray and Papell, 2000, and Strazicich et al. 2001), find more evidence supporting the structuralist theory of unemployment.

Nevertheless, unemployment shocks may die out after a long period of time, which may also increase the likelihood of Type II errors through the unit root and stationarity tests used in these studies. In this situation unit root tests may fail to reject the null hypothesis when the processes are fractionally integrated with a differencing parameter close to but less than 1.[2] In this case, although the variable is not a stationary process, it still presents mean reversion. Fractional integration analysis thus provides us with greater analytical flexibility: by estimating the value of *d*, we can make an assessment about the validity of alternative theories of unemployment (as summarised in Table 1). Thus, recent contributions Gil-Alana (2001a, b, 2002) and Caporale and Gil-Alana (2007, 2008), among others, conclude that by means of applying ARFIMA models, the structuralist view is more appropriate as a characterisation of European unemployment, while the NAIRU explains better the behaviour of the US data.

[2] See Diebold and Rudebusch (1991), Hassler and Wolters (1994) and Lee and Schmidt (1996).

Finally, the existence of non-linearities is also accounted for, given that the unemployment rate's speed of adjustment towards equilibrium may be dependent on the degree of misalignment (KSS). This implies that there may exist a threshold of values for the unemployment rate where the variable behaves as a unit root (inner regime), but when the variable departs from the inner regime, it behaves as a mean reverting process. In policy terms, this implies that the authorities should not implement policy measures for small deviations of unemployment from the equilibrium, given that the costs will offset the benefits. However, when unemployment reaches higher values, policy intervention to affect the underlying fundamentals may reduce actual unemployment rates. Examples of empirical papers that deal with non-linearities in unemployment rates are Bianchi and Zoega (1998), Skalin and Teräsvirta (2002) and Caporale and Gil-Alana (2007, 2008).

Although there are a number of empirical papers that analyse which hypothesis best fits unemployment data for industrialised countries, this issue has not been analysed so often in the CEECs. To the best of our knowledge, only Camarero et al. (2005, 2008), León-Ledesma and McAdam (2004), and Cuestas and Ordóñez (2009) have tested for the order of integration of unemployment in these countries, by means of applying panel-unit root tests, controlling for structural breaks and non-linear trends. In general, these authors find evidence in favour of the structuralist view in most of these countries.

4. Econometric Methodology

In this section we complement the studies discussed above, by applying the recently developed LS and KSS unit root tests along with fractionally integrated methods to a pool of CEEC unemployment data.

Lee and Strazicich (LS, 2003) develop a unit root test that takes into account the possibility of two structural changes. According to these authors, earlier unit root tests with structural changes, such as those from Zivot and Andrews (1992) and Lumsdaine and Papell (1997), may provide misleading conclusions when the unit root hypothesis is rejected. Accepting the alternative hypothesis implies that the series has structural changes, which can be *I(0)* or *I(1).* This means that rejecting the null does not always imply the series is trend-stationary, because the null hypothesis of those earlier unit root tests with structural breaks does not incorporate breaks. In order to overcome this, LS propose a two-break minimum Lagrange Multiplier (LM) unit root test, in which the alternative hypothesis unambigously indicates trend-stationarity. This test can be performed by estimating the following equation

$$\Delta y_t \;=\; \delta' \Delta Z_t + \phi \overline{S}_{t-1} + u_t, \tag{5}$$

where Z_t is a vector of exogenous variables, $\overline{S}_t = y_t - \overline{\psi}_x - Z_t \overline{\delta}$, $t = 2,... T;$ $\overline{\delta}$ are the estimated values of δ in the regression model (5), and $\overline{\psi}_x$ is given by $y_1 - Z_1 \overline{\delta}$. To define the null and alternative hypotheses, let us consider the following DGP

$$y_t \;=\; \delta' Z_t + e_t, \qquad e_t = \beta e_{t-1} + \varepsilon_t, \tag{6}$$

where $\varepsilon_t \sim NIID(0, \sigma^2)$. Given that we are testing for mean reversion in unemployment rates we will only consider the case where there are shifts in levels without linear trends in the deterministic components. For a two-break model, we can define $Z_t = [1, D_{1t}, D_{2t}]'$, where $D_{jt} = 1$ for $t \geq T_{Bj+1}$, j = 1, 2, and 0 otherwise. T_{Bj} is the date of the breaking point. Thus, the null and alternative hypotheses can be defined as follows; $H_0 \equiv y_t = \alpha_0 + d_1 B_{1t} + d_2 B_{2t} + y_{t-1} + \vartheta_{1t}$ and $H_1 \equiv y_t = \alpha_1 + d_1 D_{1t} + d_2 D_{2t} + y_{t-1} + \vartheta_{2t}$, where ϑ_{1t} and ϑ_{2t} are stationary error terms, B_{1t} and B_{2t} = 1 for $t = T_{B1} + 1$ and $t = T_{B2} + 1$, respectively, and 0 otherwise.

Hence, the unit root hypothesis is $H_O \equiv \phi = 0$, and the test statistics are given by $\overline{\rho} = T\overline{\phi}$ and τ, the latter being the t-statistic associated with ϕ. The two-break minimum LM unit root test selects the time breaks endogenously by minimising the test statistic.

It is important to bear in mind that if the speed of adjustment is asymmetric, i.e. it actually depends on the degree of misalignment from the equilibrium, Dickey-Fuller type tests may incorrectly conclude that the series contains a unit root, when in fact is a non-linear globally stationary process. In this case, we may define a DGP with two regimes, that is, an inner regime where the variable is assumed to be *I(1)* and an outer regime, where the variable may or may not be a unit root. The transition between regimes is smooth rather than sudden. In order to account for the possibility of non-linearities in the autoregressive parameter, we have also applied the KSS unit root test. Kapetanios, Shin and Snell (KSS, 2003) propose a unit root test to analyse the order of integration of the variable in the outer regime. In other words,

$$y_t = \beta y_{t-1} + \phi y_{t-1} F(\theta; y_{t-1}) + \varepsilon_t , \tag{7}$$

where ε_t is $iid(0,\sigma^2)$ and $F(\theta; y_{t-1})$ is the transition function, which is assumed to be exponential (ESTAR),

$$F(\theta; y_{t-1}) = 1 - exp\{-\theta y_{t-1}^2\}, \tag{8}$$

with $\theta > 0$. In practice, it is common to rewrite equation (7) as

$$\Delta y_t = \alpha y_{t-1} + \gamma y_{t-1}(1 - exp\{-\theta y_{t-1}^2\}) + \varepsilon_t , \tag{9}$$

in order to apply the test. The null hypothesis $H_o : \theta = 0$ is tested against the alternative $H_1 : \theta > 0$, i.e. we test whether the variable is an *I(1)* process in the outer regime. Note that equation (9) assumes that the transition parameter in the transition function

$$F(\theta; y_{t-1}) = 1 - exp\{-\theta (y_{t-1} - c)^2\},$$

is equal to 0.

In a recent contribution, Kruse (2010) proposes a unit root test based on the KSS idea, but relaxing the hypothesis that $c = 0$. According to Kruse (2010), this test improves the power and size of the KSS when $c \neq 0$. The test is based on the following Taylor approximation,

$$\Delta y_t = \delta_1 y_{t-1}^3 + \delta_2 y_{t-1}^2 + \delta_3 y_{t-1} + error .$$

KSS, claims that in order to obtain a more powerful test, it is necessary to impose $\delta_3 = 0$. Also, we can incorporate lags of the dependent variable to control for autocorrelation. To test the null hypothesis of a unit root, i.e., $H_0 : \delta_1 = \delta_2 = 0$ versus a globally stationary ESTAR process, $H_1 : \delta_1 < 0, \delta_2 \neq 0$, Kruse (2010) proposes a τ - test, which is a version of the Abadir and Distaso (2007) Wald test.

In addition, in order to take into account the possibility of a three-regime SETAR model in the DGP, we apply Bec, Ben Salem and Carrasco's (BBC, 2004) unit root test. According to these authors for some economic variables, assuming an outer regime and an inner regime may be too restrictive. This implies that the variable's reaction after a shock does not depend on the sign of the shock, but only on its magnitude. However, for unemployment this assumption may be implausible. It is well known that rates of unemployment tend to increase much faster after a negative shock than they decrease after a positive shock. This justifies the use of a model with three regimes, i.e. a central regime, a lower regime and an upper regime. BBC propose the following base model

$$\Delta y_t = \begin{cases} \alpha_{10} + \alpha_{11}\Delta y_{t-1} + ... + \alpha_{1p-1}\Delta y_{t-p+1} + \rho_1 y_{t-1} + \varepsilon_t, if \quad y_{t-1} \le -\lambda \\ \alpha_{20} + \alpha_{21}\Delta y_{t-1} + ... + \alpha_{2p-1}\Delta y_{t-p+1} + \rho_2 y_{t-1} + \varepsilon_t, if \quad | y_{t-1} | < \lambda \\ \alpha_{30} + \alpha_{31}\Delta y_{t-1} + ... + \alpha_{3p-1}\Delta y_{t-p+1} + \rho_3 y_{t-1} + \varepsilon_t, if \quad y_{t-1} \ge \lambda \end{cases} . \tag{10}$$

Denoting $\alpha_j = (\alpha_{j1,...,}\alpha_{jp-1})'$, $j=1,2,3$, $I_{t<} = I\{y_{t-1} \le -\lambda\}, I_t = I\{| y_{t-1} | < -\lambda\}$, $I_{t>} = I\{y_{t-1} \ge \lambda\}$, $u =_t \Delta y_t$, and $u_{t-1}^p = (\Delta y_{t-1},...,\Delta y_{t-p+1})$, the model above can be rewritten as

$$u_t = x'_t \beta + \varepsilon_t, \tag{11}$$

with $\beta = (\alpha'_1, \alpha'_2, \alpha'_3, \alpha_{10}, \alpha_{20}, \alpha_{30}, \rho_1, \rho_2, \rho_3)'$

and $x_t = (I_{t<}u_{t-1}^p, \bar{I}_t u_{t-1}^p, I_{t>}u_{t-1}^p, I_{t<}, I_{t<}u_{t-1}, \bar{I}_t, \bar{I}_t y_{t-1}, I_{t<}, I_{t<}y_{t-1})'$.

In order to test $H_0 : \rho_1 = \rho_2 = \rho_3 = 0$, the authors consider the following Wald, Lagrange Multiplier and Likelihood Ratio tests

$$W_T(\lambda) = \frac{1}{\hat{\sigma}^2}\hat{\rho}'\left[R\left(\sum_{t=1}^{T} x_t x'_t\right)^{-} R'\right]^{-}\hat{\rho},$$

$$LM_T(\lambda) = \frac{1}{\hat{\sigma}^2}\left[\sum_{t=1}^{T} x_t \tilde{\varepsilon}_t\right]'\left[\sum_{t=1}^{T} x_t x'_t\right]^{-}\left[\sum_{t=1}^{T} x_t \tilde{\varepsilon}_t\right],$$

and

$$LR_T(\lambda) = T \ln\left(\frac{\tilde{\sigma}^2}{\hat{\sigma}^2}\right),$$

where $\hat{\rho} = (\hat{\rho}_1, \hat{\rho}_2, \hat{\rho}_3)$, R is the 3 × *(*3*p* + 6*)* selection matrix so that $R\hat{\beta} = \hat{\rho}$, and $\hat{\varepsilon}_t = u_t - x'_t \hat{\beta}$, which comes from the unrestricted regression (11) with $\hat{\beta}$ being the ordinary least squares estimator of β and $\hat{\sigma}^2 = \sum_{t=1}^{T} \hat{\varepsilon}_t^2 / T$. Let $\tilde{\beta}$ be the restricted ordinary least squares estimator of β in (11) under the constraint $\rho_1 = \rho_2 = \rho_3 = 0$, with $\tilde{\varepsilon}_t = u_t - x'_t \tilde{\beta}$ and $\tilde{\sigma}^2 = \sum_{t=1}^{T} \tilde{\varepsilon}_t^2 / T$. The notation A^- denotes the Moore-Penrose generalised inverse of matrix *A.* BBC (2004) propose to chose λ as the value that minimises the sum of squared residuals.

In addition, and in order to consider the possibilty of non-integer orders of integration, fractionally integrated processes will also be examined. Here, we consider processes of the form

$$y_t = \alpha + \beta t + x_t; \qquad (1 - L)^d x_t = u_t; \qquad t = 1, 2, ..., \tag{12}$$

where u_t is *I(0)* and *d* may be a real value. In this context, we perform a version of Robinson's (1994) procedure, testing the null hypothesis

$$H_o : d = d_o, \tag{13}$$

in (12) for any real value d_o, including stationary ($d < 0.5$) and nonstationary ($d \geq 0.5$) hypotheses. We employ this procedure based on the following facts: first, this method has a standard (normal) limiting distribution, which holds independently of the inclusion or not of deterministic terms and the way the *I(0)* disturbances are modelled. It does not impose Gaussianity with a moment condition only of order 2 required, and it seems to be robust against conditional heteroskedastic errors. Moreover, it is the most efficient procedure in the Pitman sense against local departures from the null. The functional form of the test statistic can be found in any of the numerous empirical applications of this procedure (e.g., Gil-Alana and Robinson, 1997; Gil-Alana, 2000, 2004). We have to bear in mind that fractional integration models provide us with a higher degree of flexibility when analysing the order of integration of the series, given that the degree of differentiation is allowed to take non-integer values. We can then consider unit root tests, which only take *I(1)* or *I(0)* processes, as particular cases of the *I(d)* models, therefore these two techniques should be interpreted as complementary.

5. Results

In this section we analyse the unemployment rates for a pool of CEECs, specifically the Czech Republic, Estonia, Hungary, Latvia, Lithuania, Poland, Romania, the Slovak Republic and Slovenia. Aggregate average EU-15 unemployment rates have also been included for comparison purposes. We use monthly harmonised and seasonally adjusted unemployment rates[3] for 1998:1-2007:12 from *Eurostat*. Note that by starting in 1998, we also are analysing unemployment in the aftermath of the Russian crisis.

[Insert Figure 1 about here]

As can be seen from Figure 1, unemployment rates in these CEECs have, with the notable exception of Hungary, fallen in recent years. Also, there appears to be a degree of comovement between the unemployment rates, again with the exception of Hungary, which may be a sign of the degree of integration of these countries' labour markets (Cuestas and Ordóñez, 2009). It also appears that in the aftermath of the Russian crisis, the unemployment rates of the Czech Republic, Estonia, Lithuania and the Slovak Republic increased significantly, reaching double-digit levels.

In Table 2, we display the results of the KSS, Kruse (2010), BBC (non-linear) unit root tests and Ng and Perron (2001) (linear) unit root tests. The latter authors proposed tests based on previously developed unit root tests, in order to improve their performance in terms of size and power (see Ng and Perron, 2001, for further details). From this table we can highlight the fact that for most countries the unemployment rates appear to be non-stationary *I(1)*. The exceptions are Hungary, Estonia and Lithuania, with the non-linear test, and the EU-15 with the Ng and Perron (2001) test.

[Insert Tables 2 and 3 about here]

[3] Although the results presented here have been obtained without any transformation of the data, we have also run our analysis by taking logarithms and using a logistic function to transform the data, in order to avoid the problem of testing the order of integration for bounded data (see Wallis, 1987). The conclusions are the same regardless of the data used. To save space, the results have been omitted here but are available, upon request, from the authors.

In order to take into account the possibility of structural changes in the DGP, we present in Table 3 the results of the LS test, with two structural breaks in the drift, without linear trend. The results point to the fact that only the EU-15 and Lithuania appear to have unemployment represented by stationary *I(0)* processes around a breaking drift.

Next, we test for the order of integration of the unemployment rates by means of estimating the differencing parameter *d*. The first model tested is

$$y_t \; = \; \alpha \; + \; \beta t \; + \; x_t; \qquad (1 \, - \, L)^d \, x_t \; = \varepsilon_t. \tag{14}$$

Table 4 reports the estimates of *d* in (14) based on white noise disturbances. We observe here that if we do not include regressors, the unit root cannot be rejected for any of the series. However, including an intercept, or an intercept with a linear trend, the *I(1)* hypothesis is rejected in most cases in favour of orders of integration above 1. The exceptions are Latvia, Romania and Slovenia; in these cases we cannot reject the *I(1)* hypothesis. However, the results presented above may be biased because of the lack of autocorrelation for the *d*-differenced processes. Therefore, in what follows we assume that u_t in (14) is AR(1). Employing higher AR orders, the results were substantially the same. Therefore, the model considered now is

$$y_t \; = \; \alpha \; + \; \beta t \; + \; x_t; \qquad (1 \, - \, L)^d \, x_t \; = \, u_t; \qquad u_t \; = \; \rho u_{t-1} \; + \; \varepsilon_t. \tag{15}$$

[Insert Tables 4 and 5 about here]

The results are displayed in Table 5. In general, we observe five series where the *I(0)* hypothesis cannot be rejected: for Latvia, Lithuania, Romania, Slovenia and EU-15. Therefore, for these countries, a simple AR(1) model may be an adequate specification. For the remaining cases, *d* is strictly above 0, implying long memory, but smaller than 0.5, suggesting that the series are stationary and mean reverting. We also observe substantial differences, depending on the inclusion or not of deterministic terms. Thus, if no regressors are included, most of the estimates are positive but close to 0. However if an intercept, or an intercept with a linear trend, is included the estimates are significantly above 0 in some cases, e.g., Poland (0.358 with an intercept, and 0.400 with a linear trend); the Czech Republic (0.358 with an intercept, and 0.271 with a linear trend); and the Slovak Republic (0.268 with an intercept, and 0.179 with a time trend).

Given the similarities observed in the results for the two cases of an intercept and an intercept with a linear time trend, it is appropriate next to ask if the time trend is required in these data. For this purpose we can consider a joint test of the null hypothesis

$$H_o: \ \beta = 0 \text{ and } d = d_o, \tag{16}$$

in (15) against the alternative

$$H_a: \ \beta \neq 0 \text{ or } d \neq d_o. \tag{17}$$

This possibility is not addressed in Robinson (1994), although Gil-Alana and Robinson (1997) derived a similar LM test of (16) against (17). Though we do not report the results here, we obtain strong evidence against the time trend in all cases for the two types of disturbances.

A noticeable feature observed across Tables 4 and 5 is that the results in terms of the estimation of d differ substantially, depending on the specification of the error term. Thus, if it is a white noise process, most of the estimates are above 1, implying a lack of mean reverting behaviour. However, deploying the more flexible *ARFIMA(1, d, 0)* model, the estimates of d are substantially smaller, and the dependence across time is now described by the two (fractional differencing and autoregressive) parameters. The results of LR tests in all cases strongly support the model with autocorrelated errors. This implies that unemployment rates in all the countries analysed are mean reverting processes, which may be consistent with the NAIRU hypothesis.

[Insert Table 6 about here]

Table 6 displays the parameter estimates for the model with an intercept and AR(1) disturbances. We observe that the AR coefficients are large, being above 0.9 in the majority of cases, implying a long degree of persistence in the series.

[Insert Figure 2 about here]

Finally, we have computed the impulse responses (and the 95% confidence bands) based on the results displayed in Table 6. The plots in Figure 2 indicate that all the unemployment series are mean reverting though highly persistent. In fact, for the Czech Republic, Estonia, Poland and the Slovak Republic, the values increase initially, decreasing only in the long run.

The same happens for Hungary, although the decrease starts earlier. For Lithuania, the decrease is monotonic though extremely slow, whilst for Latvia, Slovenia and the EU-15 the decrease is also monotonic though faster. Finally, for Romania, the responses decrease rapidly (almost exponentially) to zero. A lightly-protected labour market may explain this behaviour. Also, we have to bear in mind that official Romanian unemployment rates have always been single-digit, implying that the market is able to cancel out any negative shock in a relatively short period of time.

To sum up, neither the NAIRU nor the structuralist view of unemployment are supported by the unit root tests. However, these results contrast with those obtained by the fractional integration analysis. Accordingly, we find that the unemployment rates in the CEECs are mean reverting processes, but with a high degree of persistence aftter a shock. This supports the NAIRU hypothesis. This is not surprising, given that the unit root tests tend to suffer from power problems when the series present a high degree of persistence. This has been controlled for in the present study by the fractional integration tests.

6. Conclusions

In this paper we have analysed the unemployment dynamics in a group of CEECs, by means of applying unit root tests that control for structural changes, non-linearities and fractionally integrated alternatives. The results of the unit root tests point in general to the non-rejection of the unit root process, implying that for the majority of these countries the hysteresis hypothesis of unemployment fits the data. On the other hand, allowing for fractional integration as a more flexible model, we find that in all the countries analysed, the unemployment rates are mean reversting processes, although with a high degree of persistence, fulfilling the NAIRU hypothesis.

Our results pinpoint the fact that labour flows from new EU countries should not result from asymmetric shocks affecting only CEECs. Although shocks tend to be quite persistent in most cases, their effects tend to die out. The authorities should, hence, focus their policy decisions on restructuring those areas (industries, legislation, etc.) that may generate frictions in the process of adjustment towards equilibrium, i.e. making labour markets more flexible in order to reduce the half life of the shocks on unemployment. This will reduce the effect of asymmetric shocks, and therefore migration pressures within the EU-27.

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Table 1: Order of integration of unemployment and hypothesis fulfilled

Order of Integration	Hypothesis
$d \in (0,0.5)$	NAIRU
$d \in (0,0.5)$ + *structural changes*	Structuralist view point
$d \in [0.5,1]$	Persistence
$d \geq 1$	Hysteresis

Table 2: KSS, Kruse (2010), BBC and Ng-Perron unit root test results

Country	Test	Statistic	CV (5%)	CV (10%)
Czech Rep.	MZ_{α}	-1.70709	-8.10000	-5.70000
	MZ_{t}	-0.85635	-1.98000	-1.62000
	MSB	0.50164	0.23300	0.27500
	MP_{t}	13.3083	3.17000	4.45000
	$\hat{t}_{NLD}$	-0.05804	-2.907082	-2.632633
	τ	4.28404	10.1700	8.60000
	Wald	14.83406	18.40000	16.1810
Estonia	MZ_{α}	-1.16610	-8.10000	-5.70000
	MZ_{t}	-0.50351	-1.98000	-1.62000
	MSB	0.43179	0.23300	0.27500
	MP_{t}	13.0590	3.17000	4.45000
	$\hat{t}_{NLD}$	-0.05195	-2.907082	-2.632633
	τ	1.22267	10.1700	8.60000
	Wald	17.42805*	18.40000	16.1810
Hungary	MZ_{α}	-1.01914	-8.10000	-5.70000
	MZ_{t}	-0.69858	-1.98000	-1.62000
	MSB	0.68546	0.23300	0.27500
	MP_{t}	23.3166	3.17000	4.45000
	$\hat{t}_{NLD}$	-3.32893**	-2.907082	-2.632633
	τ	1.88253	10.1700	8.60000
	Wald	9.061678	18.40000	16.1810
Latvia	MZ_{α}	1.67346	-8.10000	-5.70000
	MZ_{t}	1.35061	-1.98000	-1.62000
	MSB	0.80708	0.23300	0.27500
	MP_{t}	53.9926	3.17000	4.45000
	$\hat{t}_{NLD}$	-0.08886	-2.907082	-2.632633
	τ	2.66935	10.1700	8.60000
	Wald	15.47794	18.40000	16.1810

Lithuania	MZ_{α}	-1.13434	-8.10000	-5.70000
	MZ_t	-0.44243	-1.98000	-1.62000
	MSB	0.39004	0.23300	0.27500
	MP_t	12.0002	3.17000	4.45000
	$\hat{t}_{NLD}$	-1.01710	-2.907082	-2.632633
	τ	2.52092	10.17000	8.60000
	Wald	20.05629**	18.40000	16.1810

Poland	MZ_{α}	-3.56435	-8.10000	-5.70000
	MZ_t	-1.30126	-1.98000	-1.62000
	MSB	0.36508	0.23300	0.27500
	MP_t	6.87702	3.17000	4.45000
	$\hat{t}_{NLD}$	-0.91034	-2.907082	-2.632633
	τ	1.42063	10.17000	8.60000
	Wald	8.851714	18.40000	16.1810
Romania	MZ_{α}	-1.25364	-8.10000	-5.70000
	MZ_t	-0.78939	-1.98000	-1.62000
	MSB	0.62968	0.23300	0.27500
	MP_t	19.4690	3.17000	4.45000
	$\hat{t}_{NLD}$	-1.51441	-2.907082	-2.632633
	τ	3.06169	10.17000	8.60000
	Wald	11.10734	18.40000	16.1810
Slovak Rep.	MZ_{α}	-1.32121	-8.10000	-5.70000
	MZ_t	-0.75247	-1.98000	-1.62000
	MSB	0.56953	0.23300	0.27500
	MP_t	16.8858	3.17000	4.45000
	$\hat{t}_{NLD}$	0.90431	-2.907082	-2.632633
	τ	5.84609	10.1700	8.60000
	Wald	12.93910	18.40000	16.1810

Slovenia	MZ_{α}	2.62513	-8.10000	-5.70000
	MZ_t	1.65152	-1.98000	-1.62000
	MSB	0.62912	0.23300	0.27500
	MP_t	40.7605	3.17000	4.45000
	$\hat{t}_{NLD}$	-0.46632	-2.907082	-2.632633
	τ	2.91827	10.17000	8.60000
	Wald	5.026566	18.40000	16.1810
EU-15	MZ_{α}	-6.98324*	-8.10000	-5.70000
	MZ_t	-1.67138*	-1.98000	-1.62000
	MSB	0.23934*	0.23300	0.27500
	MP_t	4.19484*	3.17000	4.45000
	$\hat{t}_{NLD}$	-0.82184	-2.907082	-2.632633
	τ	0.73155	10.17000	8.60000
	Wald	1.154467	18.40000	16.1810

Note: The order of lag to compute the tests has been chosen using the modified AIC (MAIC) suggested by Ng and Perron (2001). The Ng-Perron tests include an intercept, whereas the KSS, Kruse and BBC test have been applied to the de-meaned data, $\hat{t}_{NLD}$, τ and *Wald* respectively. The critical values for the Ng-Perron, BBC and τ tests have been taken from Ng and Perron (2001), BBC and Kruse (2010) respectively, whereas those for the KSS have been obtained by Monte Carlo simulations with 50,000 replications.

Table 3: LS unit root tests results

Country	Tb1	Tb2	Test statistic
Czech Rep.	1998:12	1999:05	-1.87220
Estonia	2000:10	2002:09	-2.30840
Hungary	2000:06	2003:03	-0.77865
Latvia	2004:03	2006:06	-3.14437
Lithuania	2002:03	2003:05	-3.68295*
Poland	1999:04	1999:08	-2.14604
Romania	2004:12	2005:06	-2.81521
Slovenia	2002:09	2002:12	-2.29804
Slovak Rep.	1999:01	1999:08	-2.08146
EU-15	2003:07	2006:06	-3.58400*

Note: The critical values are -3.842 and -3.504 at the 5% and 10% significance levels, respectively, and have been obtained from Lee and Strazicich (2003, Table 2). The lag length has been obtained by following a general-to-specific approach (10% significance level) from a maximum of 12 lags.

Table 4: Estimates of d in model (12) based on white noise disturbances

Country	No regressors	An intercept	A linear trend
Czech Rep.	**1.025** **(0.937, 1.148)**	1.308 (1.236, 1.404)	1.302 (1.234, 1.391)
Estonia	**1.024** **(0.932, 1.158)**	1.221 (1.139, 1.339)	1.226 (1.144, 1.341)
Hungary	**0.971** **(0.856, 1.129)**	1.180 (1.108, 1.279)	1.173 (1.104, 1.265)
Latvia	**0.977** **(0.877, 1.124)**	**0.906** **(0.825, 1.051)**	**0.880** **(0.764, 1.056)**
Lithuania	**0.996** **(0.899, 1.132)**	1.246 (1.166, 1.359)	1.254 (1.175, 1.367)
Poland	**1.017** **(0.936, 1.132)**	1.350 (1.293, 1.427)	1.350 (1.294, 1.427)
Romania	**0.943** **(0.834, 1.097)**	**0.958** **(0.836, 1.128)**	**0.959** **(0.838, 1.127)**
Slovenia	**0.976** **(0.868, 1.127)**	**1.056** **(0.962, 1.185)**	**1.057** **(0.960, 1.188)**
Slovak Rep.	**1.019** **(0.928, 1.150)**	1.250 (1.179, 1.351)	1.248 (1.180, 1.344)
EU-15	**0.962** **(0.850, 1.118)**	1.235 (1.181, 1.305)	1.225 (1.173, 1.293)

Note: The cases in bold indicate where the unit root (i.e. d = 1) cannot be rejected at the 5% level. The values in parentheses refer to the 95% confidence band.

Table 5: Estimates of d in model (15) based on AR(1) disturbances

Country	No regressors	An intercept	A linear trend
Czech Rep.	0.064 (0.042, 0.114)	0.358 (0.291, 0.466)	0.271 (0.197, 0.401)
Estonia	0.043 (0.002, 0.131)	0.281 (0.091, 0.401)	0.124 (0.058, 0.228)
Hungary	0.028 (0.008, 0.079)	0.096 (0.029, 0.187)	0.107 (0.034, 0.211)
Latvia	**-0.013** **(-0.056, 0.087)**	**-0.053** **(-0.214, 0.160)**	**-0.053** **(-0.207, 0.206)**
Lithuania	**0.010** **(-0.041, 0.122)**	**0.046** **(-0.268, 0.256)**	0.205 (0.133, 0.311)
Poland	0.068 (0.046, 0.120)	0.358 (0.296, 0.461)	0.400 (0.330, 0.495)
Romania	**0.043** **(-0.002, 0.084)**	**0.071** **(-0.067, 0.259)**	**0.083** **(-0.093, 0.352)**
Slovenia	**0.000** **(-0.026, 0.065)**	**-0.006** **(-0.137, 0.198)**	**0.123** **(-0.025, 0.268)**
Slovak Rep.	0.059 (0.036, 0.113)	0.268 (0.214, 0.348)	0.179 (0.120, 0.266)
EU-15	**-0.005** **(-0.024, 0.062)**	**-0.034** **(-0.307, 0.163)**	**0.065** **(-0.098, 0.215)**

Note: The cases in bold indicate where d = 0 cannot be rejected at the 5% level. The values in parentheses refer to the 95% confidence band.

Table 6: Parameter estimates in model (15) with an intercept and AR(1) disturbances

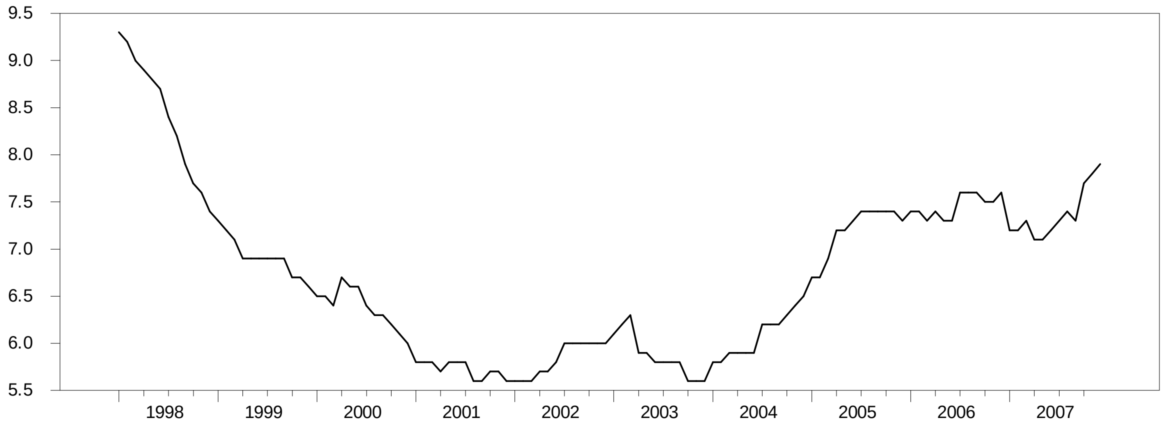
Country	intercept	d	AR coefficient
Czech Rep.	7.063 (36.010)	0.358 (0.291, 0.466)	0.956
Estonia	9.229 (27.606)	0.281 (0.091, 0.401)	0.979
Hungary	6.797 (68.950)	0.096 (0.029, 0.187)	0.982
Latvia	11.012 (45.278)	-0.053 (-0.214, 0.160)	0.995
Lithuania	11.476 (29.393)	0.046 (-0.268, 0.256)	0.997
Poland	13.805 (23.673)	0.358 (0.296, 0.461)	0.984
Romania	7.004 (78.881)	0.071 (-0.067, 0.259)	0.894
Slovenia	6.407 (97.732)	-0.006 (-0.137, 0.198)	0.985
Slovak Rep.	15.448 (38.407)	0.268 (0.214, 0.348)	0.977
EU-15	8.541 (139.670)	-0.034 (-0.307, 0.163)	0.995

Note: 2nd column: t-values in parentheses.

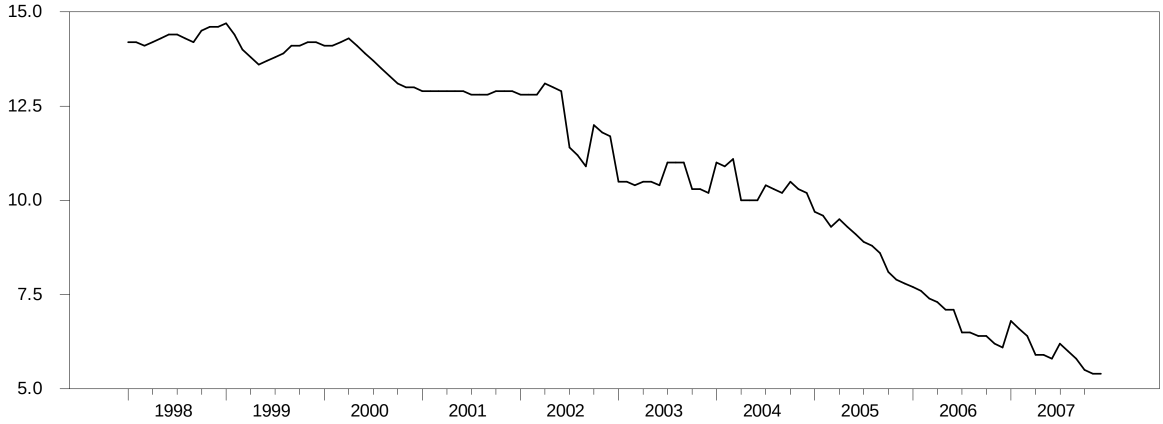
Figure 1: Unemployment rates in the CEECs

a) Czech Republic

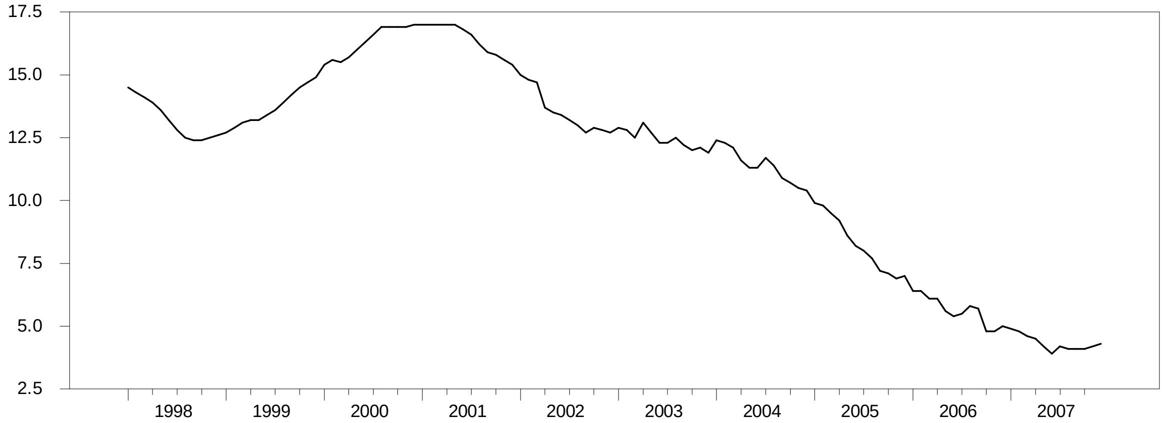
b) Estonia



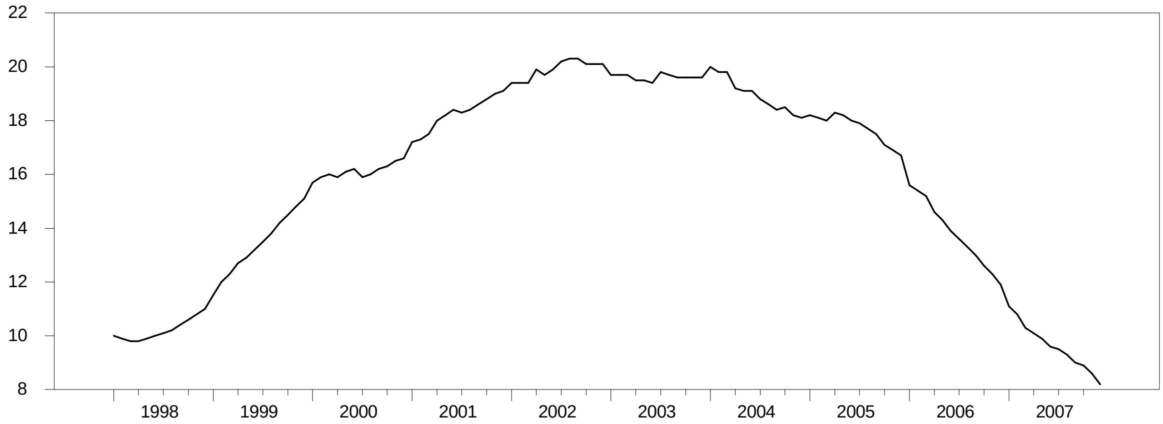
c) Hungary



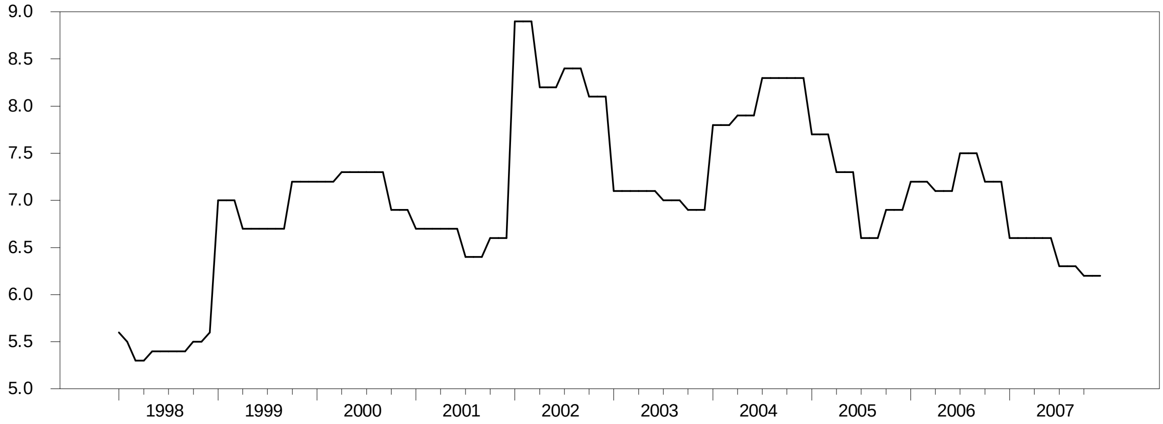
d) Latvia



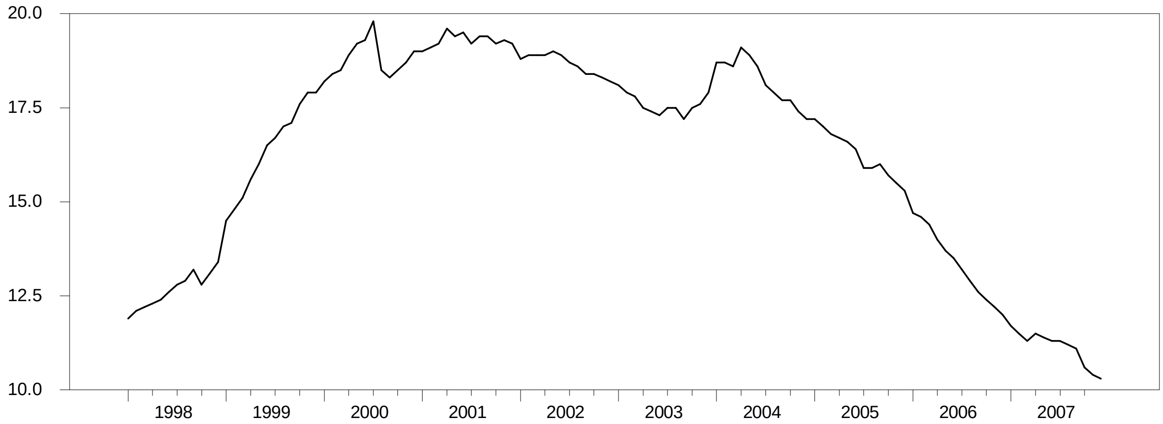
e) Lithuania



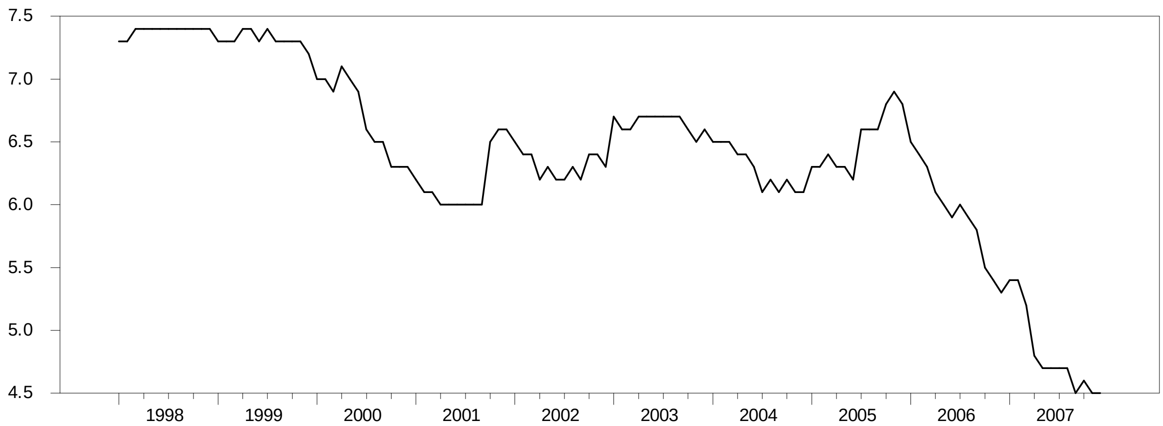
f) Poland



g) Romania

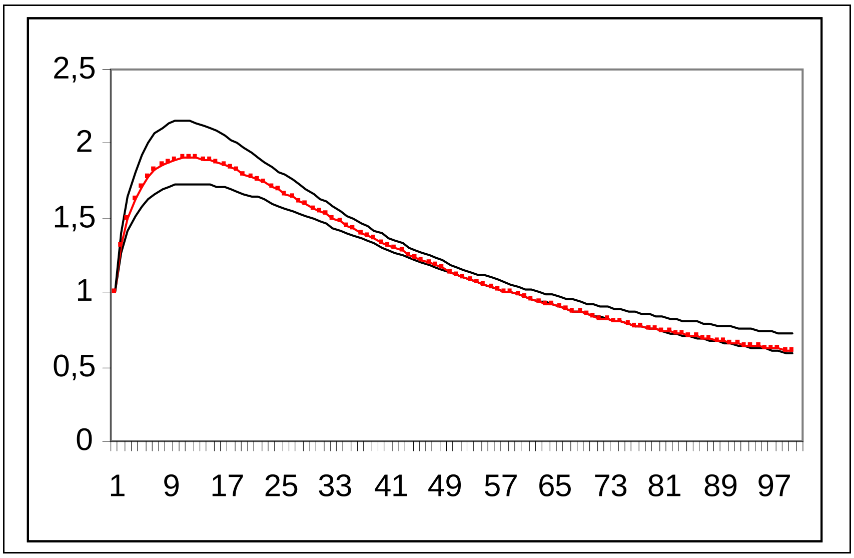


h) Slovak Republic

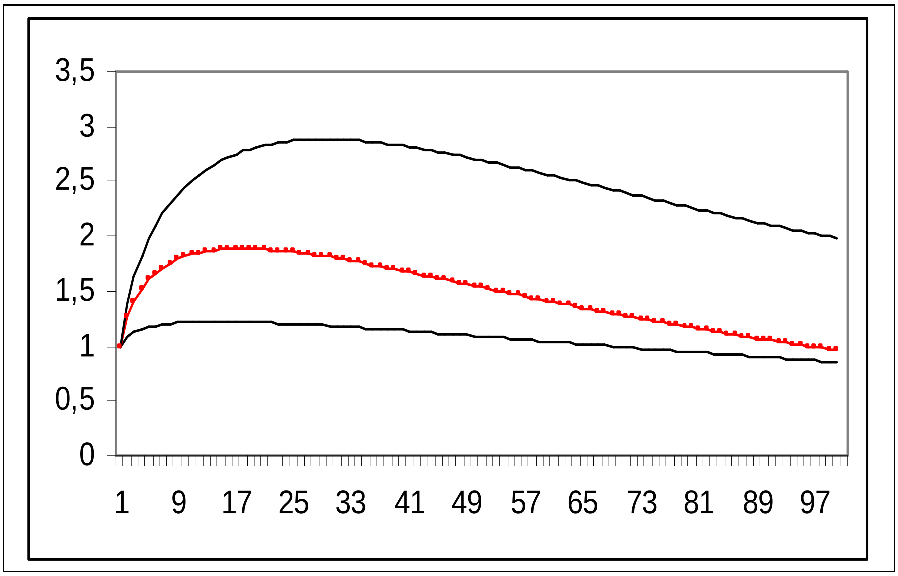


i) Slovenia

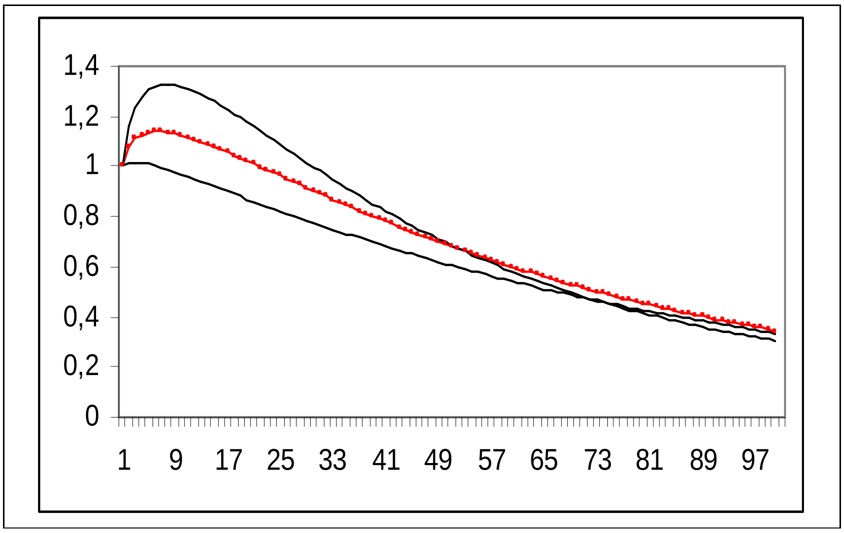
Figure 2: Impulse response functions



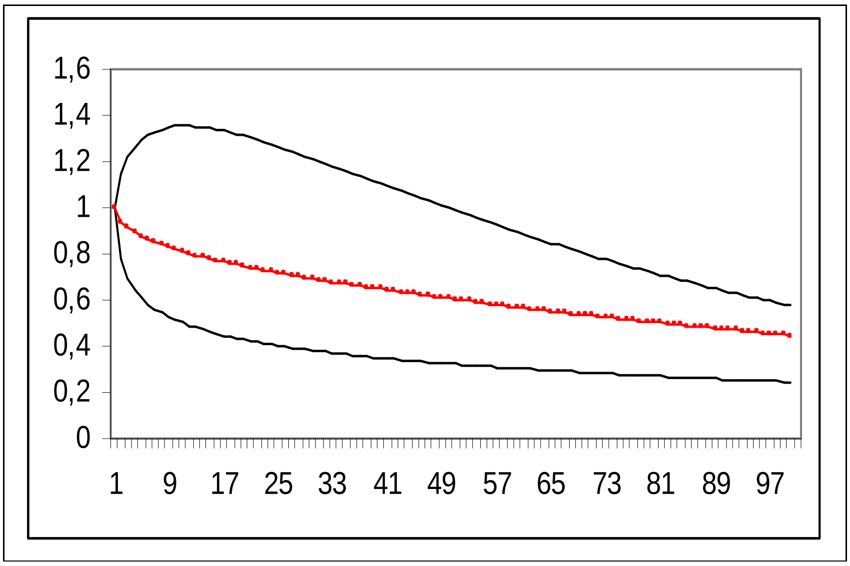
a) Czech Rep.



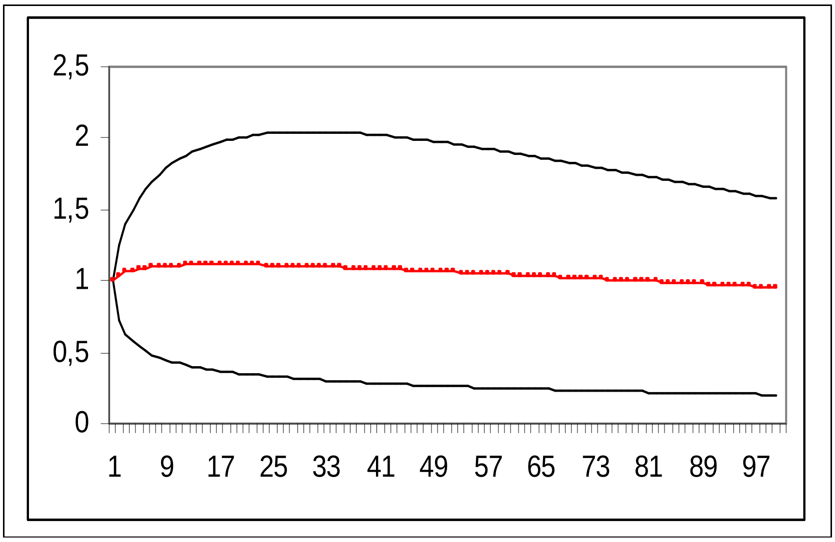
b) Estonia



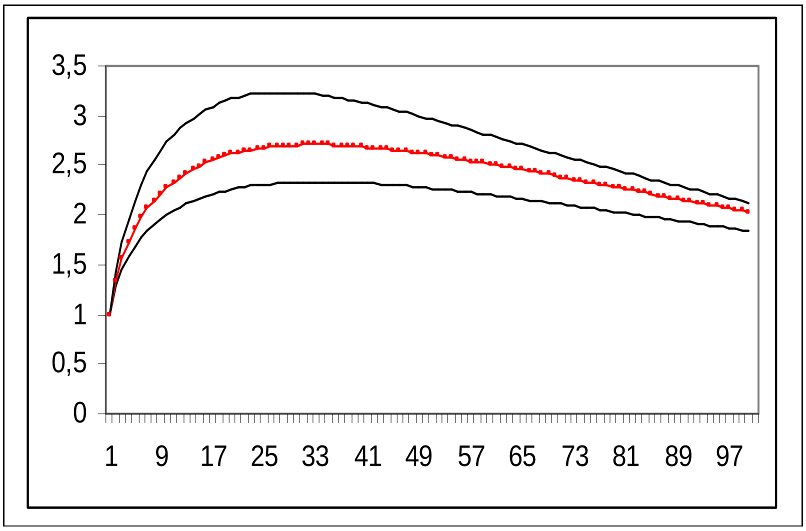
c) Hungary



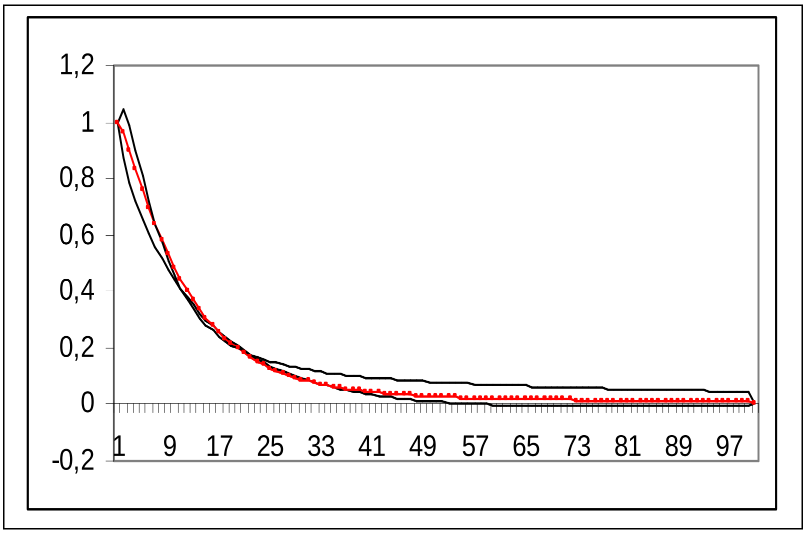
d) Latvia



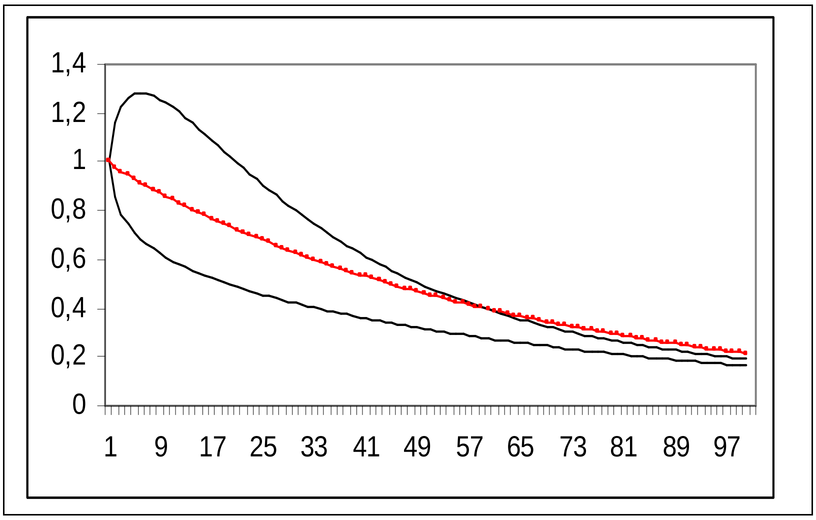
e) Lithuania



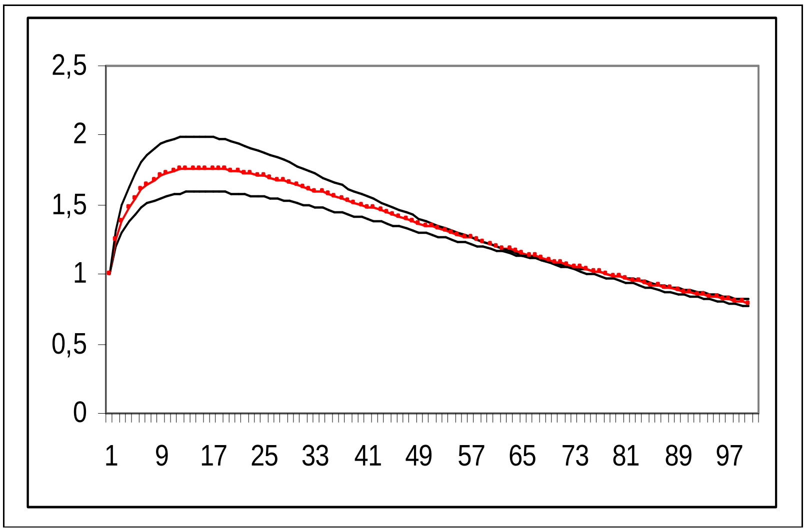
f) Poland



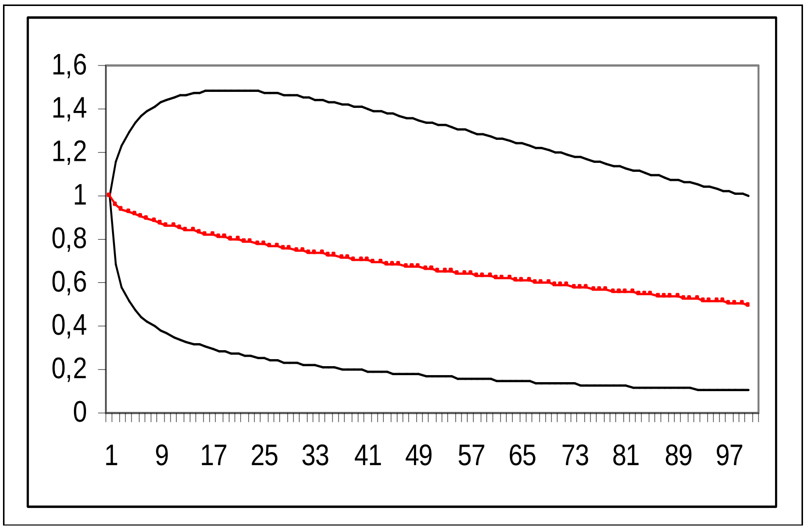
g) Romania



h) Slovenia



i) Slovak Rep.



j) EU-15