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A further investigation of the persistence hysteresis in European transtion economies

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Abstract

This paper analyses the dynamics of the unemployment rate in the eight countries from Central and Eastern Europe which joined the EU in 2004. Unit root tests allowing for nonlinearities and structural changes suggest that the unemployment rate is not stationary in most of the sample countries. Tests allowing for fractional integration, however, reveal that shocks are highly persistent, implying a slow rate of convergence to the natural rate of unemployment. The unemployment rate is least persistent in Hungary and Slovenia, more persistent in the Czech Republic, Slovakia and the Baltic States and extremely persistent in Poland. The degree of persistence appears to reflect the different levels of economic and institutional development in the countries and possibly also the role of the government.

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1. Introduction

Open unemployment was virtually non-existent in the planned economies of Central and Eastern Europe, with Yugoslavia as the exception. When the transition process started in the early 1990s, it was widely perceived that unemployment would increase in the short run, but subsequently return to low levels (Cazes and Nesporova, 2004). Events subsequently contradicted this optimistic scenario. The reorganisation of the planned economies and the coinciding deep recessions led to high unemployment rates and lower participation rates in most countries. The initial transition shocks appear to have had long-lasting effects on the unemployment rate and other labour market measures, such that by the mid 1990s the Central and Eastern European (CEE) countries had unemployment rates comparable to or exceeding levels in Western Europe. It is noticeable, though, that the unemployment rates exhibited substantial heterogeneity across the CEE countries, suggesting that country-specific factors played an important role.

In this paper we analyse the dynamic properties of the unemployment rate in the eight CEE countries that joined the European Union (EU) in 2004, i.e. the Czech Republic, Estonia, Hungary, Latvia, Lithuania, Poland, Slovakia and Slovenia.[1] The data frequency is monthly and the time sample spans the period from 1998 until the end of 2007. The sample is chosen because of data availability, but also because it comprises the period in which the countries prepared for and subsequently gained membership of the EU. The period was marked by reforms undertaken to satisfy the *Acquis Communautaire* of the EU, including structural reforms of product and labour markets. Membership of the EU in 2004 may also have had pronounced effects as labour markets in some "old" EU countries were opened for workers from the new EU members. Finally, the period was characterised by high trend growth in the CEE countries, occasionally interrupted by cyclical downturns stemming from the Russian financial crisis, other financial crises, etc. Overall, the period included a number of shocks that arguably have influenced unemployment in the countries under examination.

The analysis of the dynamic properties of unemployment rates is an important topic within applied macroeconomics, as such an analysis can provide important insights into the functioning of labour markets and arguably the entire economy. The literature provides four main theories or hypotheses regarding the behaviour of unemployment over time. The hypothesis of the *natural rate* or *NAIRU* (Non-Accelerating Inflation Rate of Unemployment) argues that there is no long-term trade off between the inflation rate and output, so the

[1] Bulgaria and Romania joined the European Union in 2007, but their late entry and data issues mean that these countries have been left out of the sample.

unemployment rate depends only on economic fundamentals in the long run (Friedman, 1968, and Phelps, 1968).[2] The early NAIRU hypothesis implied that the NAIRU would be a constant, but the *structuralist NAIRU* hypothesis later asserted that long-term unemployment level is likely to change over time along with economic fundamentals. Two more theories emerged following the oil price shocks of the 1970s and 1980s and the consequent high unemployment rates in Western Europe. The *persistence* hypothesis explains unemployment as a variable that needs a long time 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. (See Section 3 for more details.)

The dynamic properties of unemployment rates have been widely investigated, although mostly for high-income countries. The reason for the extensive literature is, at least, twofold. First, unemployment entails substantial social consequences and is typically an important policy objective. The degree of persistence is particularly important as it depicts the extent to which shocks affect the unemployment rate over time (Layard et al., 2005).[3] Second, the dynamic properties of the unemployment rate may reflect institutions, market structures and expectations formation. It can therefore provide important information on the overall functioning of the economy.

It follows from these points that the dynamic properties of the unemployment process are important for policy-making. If, for instance, unemployment follows a unit root process (*hysteresis),* policy measures may include structural reforms that reduce the frictions causing the hysteresis effect. On the other hand, should unemployment be a stationary process (NAIRU), macroeconomic policy may instead focus on measures to reduce or dampen short run shocks.

An analysis of the unemployment dynamics in the CEE countries is particularly pertinent in a broader European context since their membership has meant that migrants from the CEE countries (except Bulgaria and Romania) have free access to the labour markets in the “old” EU countries. High and persistent unemployment rates in the CEE countries may induce migratory flows of labour from the new to the old EU member countries. Within the context

[2] They refer to a vertical Phillips curve without explicitly referring to the NAIRU concept. Friedman’s natural rate of unemployment implies that it is determined exogenously, only depending on demography and unemployment benefits.

[3] The issue of persistence is particularly pertinent in case of shocks leading to higher unemployment. The global financial crisis led to a rapid increase in unemployment in many countries. OECD (2010, Ch. 5), assesses for a number of OECD countries, whether the upward shock in unemployment is likely to lead to a prolonged period of higher unemployment.

of economic integration, unemployment is one of the key variables facilitating the adjustment process towards macroeconomic equilibrium.

The empirical analysis in this paper consists of a large number of unit root tests, including non-standard tests that take into account the possibility of non-linearities in the long-term path of the variable, and fractional integration. The objective is to determine whether unemployment in each of the eight CEE countries is a stationary and mean reverting process, a non-stationary and mean reverting process or, possibly, a non-stationary and non-mean reverting process. In this way the tests give information on the degree and characteristics of unemployment persistence in this group of countries.

The literature analysing empirically the time series properties of unemployment in the CEE countries is very limited. León-Ledesma and McAdam (2004) use data for 12 Central and Eastern European countries (including Croatia and Russia) from the early 1990s to 2001. Unit root tests allowing for structural breaks reject the hysteresis hypothesis. Using a Markov switching model the authors instead find signs of jumps between two equilibria faster for the CEE countries than for the EU, one with low and one with high unemployment. Camarero et al. (2005) use data for the eight CEE countries joining the EU in 2004 (as well as Malta) from the beginning of the 1990s until the end of 2003. For all the countries the hypothesis of hysteresis is rejected in favour of stationarity with structural breaks, resulting in part from the transition process and other structural shocks. The processes vary markedly across countries. Camarero et al. (2008) employ panel data tests, accounting for structural breaks, on the same sample as Camarero et al. (2005) and reach broadly similar results. Finally, Cuestas and Ordóñez (2011) use data for eight CEE countries from 1998 to 2007 and find the unemployment rate in most cases is stationary around a non-linear trend which is common for five countries. Overall, the papers having considered the time series properties of unemployment in the CEE countries have found evidence in favour of the structuralist view in most cases, but the speed of mean reversion has generally not been assessed.

This paper contributes to the literature in three ways. First, the paper analyses unemployment dynamics during the sample period 1998-2007, i.e. during a period in which the main transition shock had waned and the CEE countries achieved rapid economic and institutional convergence. Second, the paper uses unemployment data from Eurostat for all eight CEE countries in the sample, thus uniform data collection facilitates analysis across countries. Third, the paper uses fractional integration analysis which allows for long memory processes and facilitates a detailed mapping from the time series properties to the underlying theoretical framework.

The rest of the paper is organised as follows. Section 2 discusses the unemployment experiences of the CEE countries in the sample period. Section 3 discusses economic theories of the dynamics of unemployment and summarises recent contributions on the order of integration of unemployment using time series techniques. Section 4 presents 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, Section 6 concludes the paper.

2. Labour markets and unemployment in the CEE countries

This section presents the data used in the empirical analysis and provides a brief overview of developments in the labour markets and other parts of the CEE economies, with a special emphasis on factors that may affect the persistence of unemployment.

The planned economies were generally characterised by low unemployment as the state-owned enterprises hoarded labour to ensure that they could fulfil the quantitative targets of the plan. The CEE countries in the sample began their market reforms in the late 1980s. The introduction of private ownership and financial responsibility changed the behaviour of the enterprises, as they gained incentives to shed surplus labour and introduce labour saving technologies. The disruptions caused by the transition process and the breakdown of trade among the previously planned economies led to large contractions in output. The net effect of these developments was a substantial reduction in employment in all the CEE countries, followed by lower labour force participation and the emergence of open unemployment. Participation rates have declined in all countries in the sample, mainly due to exit from the labour force of discouraged job seekers, early retirement, entrance onto disability rolls and higher education participation (Schiff et al., 2006).

In the mid-1990s unemployment was substantial in all the CEE countries. In the years before, the destruction of jobs in the previously state-owned enterprises had exceeded the creation of new jobs in the new, typically private enterprises (Boeri and Terrell, 2002). Educational and regional mismatches associated with the transition process meant that the unemployment rate remained high, i.e. a substantial proportion of total unemployment in the early transition phase was structural in character (Garibaldi and Brixiova, 1998; León-Ledesma and McAdam, 2004). Active labour market policies were used at varying degrees in different countries but with success only in some cases (Boeri, 1997).

From the mid-1990s the initial transition shock had waned in most CEE countries although the countries still experienced substantial structural change, as sectoral shifts continued and the pace of economic growth quickened. Several countries were affected by financial crises such as the Czech Republic in May 2007, when the country experienced a serious exchange rate crisis. The Russian crisis unfolded in the autumn of 1998 and affected many of the CEE countries negatively in 1998-1999, in particular in the Baltic States and Slovakia.

The process of European integration arguably also gave rise to a number of structural and economic shocks during the sample period. In 1997 five of the eight countries in the sample were invited to start negotiations on membership of the EU and, in 1999, the remaining three countries were invited to start negotiations. Before entry an applicant country had to satisfy the Copenhagen criteria, which stipulated, inter alia, that an applicant country must comply with the *Acquis Communautaire,* i.e. the body of EU laws regulating the internal market and other issues of common interest. The *Acquis Communautaire* included legislation concerning social policy, labour market policy, taxation, etc. From 1997 or 1999 until 2004 the CEE countries undertook a range of reforms and policy measures to ensure that their institutional framework was in compliance with the EU framework, some of which caused significant shocks to the economy (Cuestas and Harrison, 2010, and Cuestas and Ordóñez, 2011).

The process of institutional convergence meant also that the CEE countries became more integrated in European financial markets, as capital started flowing to the region in larger amounts than previously seen. All eight CEE countries experienced economic booms from 2003 or earlier, booms that lasted until the global financial crisis hit the region in 2008.

The economic and institutional developments are readily visible in the unemployment rates in the eight countries. Figure 1 shows for the period 1998:1-2007:12 the monthly harmonised unemployment rate as published by *Eurostat* for the eight sample countries and, for comparison, the EU-15 average. Two observations follow. First, the average unemployment rate is very high in many countries, although in all cases it varies substantially across time. The average unemployment rate is lowest for the Czech Republic, Hungary and Slovenia, while it is highest for Poland.

[Insert Figure 1 about here]

Second, a hump-shaped path of the unemployment rate is apparent for all the sample countries except Hungary and possibly Slovenia. The unemployment rate increased rapidly or remained at a high level from the beginning of the sample, in part reflecting the fallout from the Russian crisis and the setback in Western Europe after the collapse of the dot.com bubble. From 2003-04 the unemployment rate started falling markedly, essentially mirroring the high economic growth experienced at this period of time and the gradual opening of labour markets in Western Europe from May 2004 (Gabrisch and Buscher, 2006).[4] The fall in unemployment was substantial in countries such as Latvia, Lithuania, Poland and Slovakia. The fall in unemployment in Slovenia occurred relatively late, and the unemployment rate in Hungary actually increased somewhat in 2004-05, after years of overheating and deteriorating competitiveness.

The dynamic properties of the unemployment rate are arguably affected by a range of factors reflecting labour market institutions, transition processes, the economic development level and economic policy measures (Garibaldi and Brixiova, 1998; Cazes and Nesporova, 2004; Boeri and Garibaldi, 2006). To facilitate the discussion of our results, Table 1 provides data on a number of variables of potential interest.

[Insert Table 1 about here]

Table 1 shows that Slovenia was the richest country in the sample, having a per capita GDP equal to 70% of the EU-15 average in 2001. The Czech Republic, Hungary and Slovakia trailed some distance behind, while Poland and the Baltic States were the poorest countries in the sample.

The size of the government is measured as general government expenditures in total GDP and the measure correlates closely with the income levels; Slovenia and Hungary had the largest public sectors, while the Baltic States had the smallest in 2001. The overall budget sensitivities are computed by the European Commission. They measure the effect on the overall budget balance of an increase in the output gap and are often taken as a measure of the size of the automatic stabiliser. The picture is again relatively clear: Hungary and Slovenia have the largest automatic stabilisers, corresponding to their relatively large government sectors. The Baltic States have small automatic stabilisers corresponding to their relatively small government sectors.

[4] There appears to be a degree of co-movement between the unemployment rates, again with the exception of Hungary and possibly Slovenia, which suggest that common factors affected the labour markets in most of the CEE countries (Cuestas and Ordóñez, 2011).

The different regulations regarding employment protection may affect unemployment dynamics, as such regulations may affect directly the ease with which surplus labour can be dismissed, but also affect indirectly the hiring incentives of employers (OECD, 2004). Indices of employment protection legislation (EPL) are typically produced for regular contracts, temporary contracts and collective dismissal. An aggregate EPL index is a weighted average of the three indices. A higher index implies more protection for employees and is often associated with a more "rigid" labour market (Eamets and Masso, 2005). It follows from Table 1 that Slovenia and the Baltic States have the most protected labour markets. The Czech Republic, Hungary and Slovakia have the least protection, in particular for employees on temporary contracts. Eamets and Masso (2005) stress, however, that the EPL measures capture the *de jure* regulation of employment protection, which may overestimate the *de facto* conditions if enforcement is weak. This may for instance be the case for the Baltic States.

The union density is relatively low in the sample countries, with Slovenia and Slovakia representing the upper extreme with membership amounting to 40 percent of the labour force. It is noteworthy that coverage extension of union-negotiated contracts is very infrequent in the sample countries (Carley, 2002; Boeri and Garibaldi, 2006). Wage negotiations typically take place at the enterprise level and often directly between an employee and his/her employer (Carley, 2002). The exceptions are Slovenia and Slovakia, where wage bargaining is also carried out at the sectoral or intersectoral level.

Table 1 also provides data on the replacement rate of unemployment benefits at the beginning of the unemployment spell. The benefits in most of the CEE countries are less generous than seen in Western European countries, with the exception of benefits in Slovenia and Hungary (Boeri and Garibaldi, 2006).

The overall picture from Table 1 is that there are substantial differences across the countries with respect to economic development, labour market institutions and employment protection. Slovenia and Hungary stand out by having relatively high income, large and active government sectors and relatively generous provision of unemployment benefits. These two countries, however, differ with respect to their employment protection legislation. These countries have also already in the sample period experienced a high degree of convergence and resemble in many respects Western European countries. Poland and to some extent the Baltic States are at the other end of the spectrum as they are relatively poor, have small and rather inactive governments and labour markets characterised by strict formal regulations.

3. 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. The NAIRU is, however, not necessarily exogenous but might depend on macroeconomic fundamentals. However, in the short run there may be transitory deviations from the long run equilibrium. This implies that unemployment is governed by a stationary and mean reverting process, whereby shocks only have transitory effects. Hence, a simplified version of the NAIRU hypothesis, assuming the fundamentals which define the NAIRU have not changed, implies that unemployment is $I(0)$. The NAIRU hypothesis is supported if tests show that the unemployment series is a stationarity I(0) process.

Experiences in recent decades have cast doubts on the empirical validity of the constant NAIRU hypothesis, at least for European countries. A less restrictive version of the NAIRU theory is the one followed by structuralists, who argue that changes in the underlying fundamentals may affect the NAIRU permanently, resulting in structural changes and a shift from one equilibrium to another (see for instance Stockhammer, 2008). Phelps (1994) presents theoretical models to explain changes in the natural rate of unemployment, which are due to changes in economic fundamentals such as interest rates, government expenditure, capital, productivity, etc. These models use not only macro, but also micro foundations to explain shifts in unemployment rates (see also Layard et al., 2005, for a summary of these models).[5]

However, in both the NAIRU and structuralist viewpoints, the order of integration *d*, i.e. $I(d)$, may be a non-integer number between 0 and 1. Given that traditional unit root tests only consider integer numbers for the order of integration (i.e. 0 in case if stationarity and 1 for unit roots), fractional integration techniques provide us with a more flexible econometric framework, since it is possible to estimate the value of *d.* Fractionally integrated (or $I(d)$) models can be specified as

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

[5] For a recent literature review on models of determination of the NAIRU, see Karanassou et al. (2010).

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

$$(1-L)^d x_t = \left(\sum_{j=0}^{\infty} \binom{d}{j} (-1)^j L^j \right) x_t = x_t - d x_{t-1} + \frac{d(d-1)}{2} x_{t-2} - \frac{d(d-1)(d-2)}{6} x_{t-3} + \ldots \quad (2)$$

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.

Within this framework the structuralist theory implies that the unemployment rate 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). This suggests that the empirical analysis should be conducted by means of unit root tests that account for the possibility of structural changes, as traditional unit root tests may fail to reject the null hypothesis in the presence of structural breaks in the deterministic components.

Unemployment rates, by appearing to exhibit non-stationary or even explosive processes, suggest the NAIRU hypothesis may not be the appropriate theoretical starting point. In contrast, the *hysteresis* hypothesis may offer a more promising vantage point (Blanchard and Summers, 1986, 1987; Barro, 1988). According to this hypothesis, shocks to the unemployment rate will never die out, and the variable will never return to an equilibrium value; this is a characteristic of unit root or explosive processes. There are a number of explanations for this behaviour, including the possible loss of skills during spells of unemployment, powerful unions which favour employed insiders, generous protection schemes, and the social stigma of the long run unemployed (Phelps, 1972; Blanchard and Summers, 1986, 1987; Clark, 2003; and Layard et al., 2005, amongst others). Also, Cross (1995) argues that *hysteresis* is a non-linear phenomenon, explained mainly by the presence of heterogeneous agents.

That said, unemployment could eventually revert to the NAIRU after a long period of time, implying *persistence* after a shock. This might be a feature of non-stationary long memory processes characterised by $d \in [0.5, 1)$ or, alternatively, by stationary processes characterised by $d \in (0, 0.5)$ with an autoregressive parameter close to unity.

[Insert Table 2 about here]

The different unemployment hypotheses or regimes are presented in Table 2. In this paper we seek, by means of unit roots and fractional integration tests, to ascertain the most appropriate theoretical explanation for unemployment dynamics in the CEE countries. The tests, which will be explained in detail in Section 4, can provide evidentiary support for one or other theory of unemployment, by uncovering the underlying properties of the unemployment dynamics.

The scarce literature analysing the time series properties of unemployment in the CEE was reviewed in Section 1. Whereas very few studies are available for the CEE, the methodology has been used in a large number of studies on high-income economies. Early studies applied the Augmented Dickey-Fuller (Dickey and Fuller, ADF, 1979) and Phillips-Perron (Phillips and Perron, PP, 1988) unit root tests to analyse the order of integration of unemployment rates. Nelson and Plosser (1982), Blanchard and Summers (1986), Brunello (1990), Mitchell (1993), and Roed (1996) find in general that European unemployment contains a unit root, whereas the results for the USA are more ambiguous.

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, the 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 apply panel unit root tests with structural breaks find more evidence supporting the structuralist theory of unemployment (Murray and Papell, 2000, and Strazicich et al., 2001).

Unemployment shocks may die out after a long period of time, which may also increase the likelihood of Type II errors in 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.[6] 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 assess the validity of alternative theories of unemployment (as summarised in Table 1). Thus, recent contributions Gil-Alana (2001a, 2001b, 2002) and Caporale and Gil-Alana (2007, 2008), among others, conclude that by means of applying autoregressive and fractionally integrated moving average (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.

Finally, the presence of non-linearities is also accounted for, given that the speed of adjustment of the unemployment rate towards equilibrium may be dependent on the degree of misalignment, as claimed by Kapetanios et al. (2003) (KSS) and others. 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).

4. Econometric methodology

This section discusses the non-standard econometric techniques used in this paper to analyse the impact of shocks on the persistence of unemployment in the CEE countries. The methods

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

include unit root tests with structural breaks and non-linearities as well as fractional integration methods.

Starting with unit root tests with structural breaks, Lee and Strazicich (LS, 2003) develop a unit root test which 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 unambiguously indicates trend-stationarity. This test can be performed by estimating the following equation

$$\Delta y_t = \delta' \Delta Z_t + \phi \overline{S}_{t-1} + u_t , \tag{3}$$

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 (3), 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:

$$y_t = \delta' Z_t + e_t , \qquad e_t = \beta e_{t-1} + \varepsilon_t , \tag{4}$$

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: $H_0 : y_t = \alpha_0 + d_1 B_{1t} + d_2 B_{2t} + y_{t-1} + \vartheta_{1t}$ and $H_1 : y_t = \alpha_1 + d_1 D_{1t} + d_2 D_{2t} + y_{t-1} + \vartheta_{2t}$, where ϑ_{1t} and ϑ_{2t} are stationary error terms, $B_{1t} = 1$ and $B_{2t} = 1$ for $t = T_{B1} + 1$ and $t = T_{B2} + 1$, respectively, and 0 otherwise.

Hence, the unit root hypothesis is $H_0 : \phi = 0$, 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 it is a non-linear globally stationary process. In this case, we may define a DGP with two regimes, i.e., 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. KSS (2003) propose a unit root test to analyse the order of integration of the variable in the outer regime. In other words,

$$y_t = \beta\, y_{t-1} + \phi\, y_{t-1}\, F(\theta; y_{t-1}) + \varepsilon_t\,, \tag{5}$$

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),

$$F(\theta; y_{t-1}) = 1 - exp\{-\theta\, y_{t-1}^2\}, \tag{6}$$

with $\theta > 0$. In order to apply the test, it is common to rewrite equation (5) as

$$\Delta y_t = \alpha\, y_{t-1} + \gamma\, y_{t-1}(1 - exp\{-\theta\, y_{t-1}^2\}) + \varepsilon_t\,. \tag{7}$$

The null hypothesis $H_0 : \theta = 0$ 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.

In a recent contribution, Kruse (2011) proposes a unit root test based on the KSS idea, which allows for a target value of y_{t-1} different from 0. The transition function then takes the form

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

where c is an arbitrary constant. Kruse (2011) shows that this test improves the power and size of the KSS test 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 (2003) argue that it is necessary to impose $\delta_3 = 0$ in order to obtain a more powerful test. Also, we can incorporate lags of the dependent variable to control for autocorrelation. To test the null hypothesis of a unit root, $H_0 : \delta_1 = \delta_2 = 0$ versus a globally stationary ESTAR process, $H_1 : \delta_1 < 0, \delta_2 \neq 0$, Kruse (2011) proposes a τ-test, which is a version of the Wald test by Abadir and Distaso (2007).

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. These authors argue that for some economic variables it may be too restrictive to assume only an outer regime and an inner regime, as this implies that the reaction of a variable 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, as 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 (2004) propose the following base model:

$$\Delta y_t = \begin{cases} \alpha_{10} + \alpha_{11}\Delta y_{t-1} + \ldots + \alpha_{1p-1}\Delta y_{t-p+1} + \rho_1 y_{t-1} + \varepsilon_t, if \quad y_{t-1} \leq -\lambda \\ \alpha_{20} + \alpha_{21}\Delta y_{t-1} + \ldots + \alpha_{2p-1}\Delta y_{t-p+1} + \rho_2 y_{t-1} + \varepsilon_t, if \quad | y_{t-1} | < \lambda \\ \alpha_{30} + \alpha_{31}\Delta y_{t-1} + \ldots + \alpha_{3p-1}\Delta y_{t-p+1} + \rho_3 y_{t-1} + \varepsilon_t, if \quad y_{t-1} \geq \lambda \end{cases} . \tag{8}$$

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

$$u_t = x'_t \beta + \varepsilon_t , \tag{9}$$

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 the null hypothesis $H_0 : \rho_1 = \rho_2 = \rho_3 = 0$, BBC 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(3p + 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 (9), 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 (9) 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 the squared residuals.

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

$$y_t = \alpha + \beta t + x_t; \qquad (1 - L)^d x_t = u_t; \qquad t = 1, 2, \ldots, \tag{10}$$

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

$$H_0 : d = d_0, \tag{11}$$

in (10) for any real value d_0, including stationary ($d < 0.5$) and non-stationary ($d \geq 0.5$) 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, and is seen 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).[7] 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 present the results based upon the unemployment rates for the eight CEE countries in our sample: the Czech Republic, Estonia, Hungary, Latvia, Lithuania, Poland, Slovakia and Slovenia.[8] Aggregate average EU-15 unemployment rates have also been included for comparison purposes.

To establish a benchmark case, we start out with a range of unit root tests which do not take into account possible structural breaks. Table 3 shows the results of the KSS (2003), Kruse (2011), BBC (2004) (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). The unemployment rate appears to be a non-stationary $I(1)$ process for most of the sample countries when no structural breaks are allowed (but see below). The exceptions

[7] As in other standard large-sample tests, Wald and LR test statistics against fractional alternatives have the same null and limit theory as the LM test of Robinson (1994). Lobato and Velasco (2007) essentially employed such a Wald testing procedure, and, although this and other recent methods such as the one developed by Demetrescu et al. (2008) have even been shown to be robust with respect to unconditional heteroscedasticity (Kew and Harris, 2009), they require an efficient estimate of d. The LM test of Robinson (1994) therefore seems computationally more attractive.

[8] The results in this paper 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 are not reported, but are available from the authors upon request.

are Hungary, Estonia and Lithuania according to the different non-linear tests, and the EU-15 according to the Ng and Perron (2001) test.

[Insert Table 3 about here]

In order to take into account the possibility of structural changes in the DGP, we present in Table 4 the results of the LS test, with two structural breaks in the drift, but without linear trend, i.e. we only consider changes in the NAIRU. Only the EU-15 and Lithuania appear to have unemployment represented by stationary $I(0)$ processes around a breaking drift.

[Insert Table 4 about here]

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 the one given in equation (10), repeated here for convenience.

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

Table 5 reports the estimates of d in (12) based on the assumption that the disturbance term u_t is white noise (i.e., $u_t = \varepsilon_t$). We observe here that if we do not include regressors (i.e., $\alpha = \beta = 0$ in (12)), the unit root cannot be rejected for any of the series. However, including an intercept (α unknown and $\beta = 0$), or an intercept with a linear trend (α, β unknown), the $I(1)$ hypothesis is rejected in most cases, in favour of orders of integration above 1. The exceptions are Latvia and Slovenia; in these cases we cannot reject the $I(1)$ hypothesis.

[Insert Table 5 about here]

The results in Table 5 may be biased in the presence of autocorrelation of the d-differenced processes. Therefore, in what follows we assume that u_t is AR(1), in which case the model becomes

$$y_t = \alpha + \beta t + x_t; \qquad (1-L)^d x_t = u_t; \qquad u_t = \rho u_{t-1} + \varepsilon_t. \tag{13}$$

The results are shown in Table 6. In general, we observe four cases for which the $I(0)$ hypothesis cannot be rejected: Latvia, Lithuania, Slovenia and the EU-15. Therefore, for these cases, a simple AR(1) model may be an adequate specification. For the remaining countries, the estimated *d* is strictly above 0 but smaller than 0.5, hence 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 Slovakia (0.268 with an intercept, and 0.179 with a time trend).

[Insert Table 6 about here]

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

$$H_0 : \beta = 0 \text{ and } d = d_0, \tag{14}$$

in (12) against the alternative

$$H_1 : \beta \neq 0 \text{ or } d \neq d_0. \tag{15}$$

This possibility is not addressed in Robinson (1994), but Gil-Alana and Robinson (1997) derived a LM test of (14) against (15). We obtain strong evidence *against* inclusion of the time trend in all cases for the two types of disturbances (statistics not shown).

A noticeable feature observed across Tables 5 and 6 is that the results in terms of the estimation of *d* differ substantially, depending on the specification of the error term. Thus, if the error term is assumed to follow 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 jointly by the two (fractional differencing and autoregressive) parameters. The results of LR tests in all cases strongly support the model with autocorrelated errors (statistics not shown).[9] The $I(d)$ model with an intercept and AR(1) disturbances is therefore our preferred specification to be analysed and discussed in more detail.

Table 7 displays the estimates of the intercept, the order of integration d and the autoregressive coefficient for the preferred model. (The estimates of d are those also shown in Table 6 in the column labelled "With only intercept"). The intercept terms broadly reflect the different average unemployment rates in the eight countries: the estimated intercepts are lowest in the cases of the Czech Republic, Hungary and Slovenia and highest in the cases of Slovakia and Poland. It is also noticeable that the AR coefficients are very large, being above 0.95 in all cases, implying *ceteris paribus* a high degree of persistence after a shock in the series. Nevertheless, given that the estimated $d < 1$ and the estimated AR coefficient are within the unit circle, unemployment is mean reverting in all cases, although the estimates suggest that it is also highly persistent.

[Insert Table 7 about here]

The unemployment dynamics are modelled by both fractional integration and an autoregressive component in the preferred model. This complicates the presentation and interpretation of the results and we have therefore computed impulse responses (and the 95% confidence bands) based on the results in Table 7.[10] Figure 2 shows the impulse responses in bold and the confidence bands in fine curves.

[Insert Figure 2 about here]

The impulse responses confirm that the unemployment series are mean-reverting but also highly persistent in all cases. In fact, for the Czech Republic, Estonia, Lithuania, Poland and Slovakia, the unemployment rate increases initially after a shock, only to decrease in the long or very long run. Slovenia and arguably also Hungary see a monotonic fall in the unemployment rate after the initial shock. The same pattern is apparent for the EU-15.

The degree of persistence varies substantially across the eight CEE countries and the EU-15. For the EU-15 aggregate it appears that approximately half of the initial unemployment shock remains after 8-9 years. For Slovenia and Hungary less than half of the initial

[9] Moreover, employing higher AR orders, the results were broadly the same as for the model with AR(1). The results are available from the authors upon request.

[10] The second and third equations in (13) can jointly be expressed in terms of an infinite MA process, which makes it easy to obtain the impulse responses.

unemployment shock remains, suggesting the same or less persistence than found in the benchmark EU-15 case. For the Czech Republic and Slovakia a bit more than half of the initial shock remains after 8-9 years, which is slightly above the benchmark case. The Baltic States exhibit very substantial persistence; after 8-9 years the initially unemployment shock remains in Estonia and Lithuania, suggesting that the shock only fades away completely after a very long time. Latvia appears to exhibit a relatively fast dampening of shocks, but this is entirely due to the point estimate of the order of integration d being negative. A negative value of d is a somewhat unreasonable result and, in fact, the estimated d is not statistically different from 0. If it is assumed that $d = 0$ for Latvia, the implied impulse response would look very similar to the one of Lithuania (as its autoregressive coefficient is very close to 1). Thus, it is reasonable to argue that the time series properties of Latvia resemble those of the other Baltic States. Finally, Poland is a special case as the initial shock is propagated to such an extent that unemployment after 8-9 years remains substantially above the initial shock, in spite of the process being stationary. The upshot is that unemployment in Poland exhibits extreme persistence.

To sum up, the results of the unit root tests (Tables 4 and 5) and the fractional integration analysis (Tables 6 and 7) may at first glance appear contradictory. On the face of it, the unit root tests support neither the NAIRU nor the structuralist view of unemployment. The fractional integration analysis finds, however, that the unemployment rates in the CEE countries are mean reverting processes, but with a high degree of persistence after a shock. This supports the NAIRU hypothesis. The apparent contradiction is not surprising, given that unit root tests tend to suffer from power problems when the series exhibit a high degree of persistence, while fractional integration tests allow longer memory and therefore are less sensitive to this problem. In order words, traditional unit root tests may be inappropriate as they do not have sufficient power to reject a unit root when series are highly persistent.

The conclusion that the unemployment series in all eight CEE countries are stationary but very persistent may or may not be seen as being in line with other studies of unemployment dynamics in the CEE countries, often based on data from the early transition phase. Studies such as León-Ledesma and McAdam (2004) and Camarero et al. (2005) stress the importance of structural breaks and find that the unemployment series are stationary when the estimation methodology takes into account these breaks. Our findings on a more recent sample period suggest that taking into account structural breaks is not enough to confirm stationarity. The different results may stem from the early transition period being included in samples of León-Ledesma and McAdam (2004) and Camarero et al. (2005) but not in our more recent sample.

We employ fractional integration methodologies, while this has not been undertaken in earlier studies which have only allowed orders of integration equal to 0 and 1. By allowing for long memory it is possible to estimate more precisely the degree of persistence, which in this case appeared to vary substantially across the CEE countries.

The use of univariate econometrics precludes any definitive explanation of the different dynamics of the unemployment across the sample countries. There are, however, apparent patterns between the economic and labour market features discussed in Section 2 and the results obtained in this section.

Most apparently there is a close correlation between the average unemployment level during the sample period 1998:1-2007:12 and the persistence attained in the fractional integration analysis. The countries with the lowest average unemployment, Slovenia, Hungary and the Czech Republic, were also the countries found to exhibit the lowest degree of persistence. At the other extreme, Poland and the Baltic States had high average unemployment and the highest degree of persistence. Also, as summarised in Section 2, the Baltic States present the highest degree of employment protection legislation, which has been shown to inhibit unemployment flexibility (OECD, 2004). These results may suggest that there are common underlying causes that affect both the average and the persistence of the unemployment rate.

A similar pattern emerges if one considers the relative income level of the eight CEE countries (see Table 1). Slovenia, Hungary and the Czech Republic are the countries with the highest per capita income, while Poland and the Baltic States have the lowest.[11] Incidentally, the better-off countries in the sample are also those with the largest public sectors and the highest degree of counter-cyclical fiscal balances.

Turning to specific labour market factors, it is noticeable that Slovenia with the highest employment protection and Hungary with the lowest protection are the two countries with the lowest unemployment persistence. Overall there seems to be no clear correlation between the degree of employment protection and the degree of unemployment persistence.

Interestingly, there does not seem to be a clear correlation between trade union membership as reported in Table 1 and the degree of unemployment persistence. As a matter of fact, three of the countries with the lowest unionisation rate, Estonia, Lithuania and Poland, are among the countries whose unemployment exhibits the largest degree of persistence. The picture as regards unemployment benefits is similarly unclear.

[11] It is noticeable that the impulse responses for Slovenia, Hungary and arguably also the Czech Republic closely resemble the impulse response for the EU15.

The discussion above can be summarised in a few points. First, it is difficult to draw any clear link between labour market institutions and unemployment persistence in the individual CEE countries. This result is in line with conclusions in, inter alia, Cazes and Nesporova (2004). Second, there appears to be a close correlation between the level of economic development and the degree of unemployment persistence. The countries that most closely resembled the old EU countries in terms of income level and government characteristics appear also to resemble these countries in terms of unemployment persistence. Conversely, the countries that had progressed the least in terms of convergence to Western Europe were found to exhibit substantially more persistence in the unemployment rate. In this group Poland stands out with extreme persistence. Third, there is a clear correlation between the average unemployment level and the degree of persistence, suggesting that the unemployment level and its persistence are mutually dependent.

The overall conclusion would be that the economic structure and development level are of substantial importance for the persistence of unemployment in the CEE countries, possibly because of underlying factors such as matching efficiency, sectoral composition and economic policies. The findings would be broadly in line with the conclusions of Boeri and Garibaldi (2006) and Münich and Svejnar (2006).

6. Conclusions

In this paper we have analysed the unemployment dynamics in the eight CEE countries that joined the European Union in 2004, focusing on the extent of the persistence of shocks to unemployment rates. These countries are of great importance to the future of the EU, given that labour flows from the CEE countries have risen since their accession and the gradual opening of the labour markets in the EU-15 countries.

The econometric analysis consisted of unit root tests that control for structural changes, non-linearities and fractionally integrated alternatives. The unit root tests generally could not reject the hypothesis of unit root processes, but such traditional unit root tests have insufficient power to reject a unit root when responses to shocks are highly persistent. By allowing for fractional integration as a more flexible time series model, we find that in all the countries analysed, the unemployment rate is a mean reverting process, although with a high degree of persistence. This conforms with the NAIRU hypothesis when considered over a potentially very long time horizon.

There are also substantial differences in the degree of persistence across the eight CEE countries in the sample. The persistence in Slovenia, Hungary and arguably the Czech Republic is at a relatively low level, comparable to that in the EU-15. The persistence is substantial in the Baltic States and Poland, with Poland representing a case of extreme persistence. Persistence in Slovakia lies the country in between these two groups. Factors such as the average unemployment rate during the period analysed, the degree of economic development, the functioning of the government and, in some cases, the degree of employment protection legislation, are found to be correlated with the degree of prevalence of shocks.

The results have important policy implications insofar as the CEE countries may be hit by adverse or favourable unemployment shocks. The substantial persistence suggests that the effect of such shocks will remain for an extended period of time, although at varying degrees across the countries. The global financial crisis in 2008-2009 constituted a major adverse shock which increased unemployment rates in all CEE countries. The results in this paper suggest, however, that the crisis shock will have an effect on the unemployment rates in some of the CEE countries which is comparable to that experienced by the EU-15.

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Table 1: Selected statistics on labour markets and the public sector in the CEE countries

	Czech Republic	Estonia	Hungary	Latvia[a]	Lithuania	Poland	Slovakia	Slovenia
GDP per capita, PPP adjusted, % of EU15 (2001)	60.9	40.0	51.3	33.9	35.7	41.7	45.2	69.6
Government expenditures, % of GDP (2001)	44.4	34.8	47.2	34.6	36.8	43.8	44.5	47.6
Overall budget sensitivity (1995-2004)	0.37	0.30	0.46	0.28	0.27	0.40	0.29	0.44
EPL index – aggregate (2003)	2.0	2.3	1.6	2.5	2.8	2.2	1.7	2.6
EPL index – regular contracts (2003)	3.3	2.7	2.2	2.3	2.9	2.0	2.7	2.7
EPL index – temporary contracts (2003)	0.5	1.3	0.4	2.1	2.4	2.0	0.3	2.3
EPL index – collective dismissal (2003)	2.6	4.0	3.4	4.0	3.6	3.3	3.0	3.3
Membership of trade union, % (ca. 2000)	30	15	20	30	15	15	40	41
Unemployment benefits, % of average wage (ca. 2000)	50	50	64	50	25	40	60	63

[a] The employment protection legislation (EPL) indices for Latvia are from the end of the 1990s.
Sources: Eurostat, EC (2005), Tonin (2009), Eamets and Masso (2005), Carley (2002), Boeri and Garibaldi (2006).

Table 2: Order of integration of unemployment and hypothesis fulfilled

Order of Integration	Hypothesis
$d \in (0, 0.5)$	NAIRU or natural rate
$d \in (0, 0.5)$ + structural changes	NAIRU Structuralist view
$d \geq 1$	Hysteresis
$d \in [0.5, 1]$ or $d \in (0, 0.5)$ with autoregression coefficient close to 1	Persistence

Table 3: KSS, Kruse (2011), BBC and Ng-Perron unit root test results

	MZ_α	MZ_t	*MSB*	MP_t	KSS	Kruse	BBC
Czech Republic	-1.707	-0.856	0.501	13.308	-0.058	4.284	14.834
Estonia	-1.166	-0.503	0.431	13.059	-0.051	1.222	17.428*
Hungary	-1.019	-0.698	0.685	23.316	-3.328**	1.882	9.061
Latvia	1.673	1.350	0.807	53.992	-0.088	2.669	15.477
Lithuania	-1.134	-0.442	0.390	12.000	-1.017	2.520	20.056**
Poland	-3.564	-1.301	0.365	6.877	-0.910	1.420	8.851
Slovakia	-1.321	-0.752	0.569	16.885	0.904	5.846	12.939
Slovenia	2.625	1.651	0.629	40.760	-0.466	2.918	5.026
EU-15	-6.983*	-1.671*	0.239*	4.194*	-0.821	0.731	1.154

Note: The *M*-versions are tests upgraded by Ng and Perron (2001). The MZ_α test is the modified version of the Phillips (1987) test, the MZ_t test is the modified version of the Phillips and Perron (1988) test, the *MSB* is the modified version of the Bhargava (1986) test, and the MP_t is the modified version of the Point Optimal Test by Elliot, Rothenberg and Stock (1996). The order of lags to compute the tests has been chosen using the modified AIC (MAIC) suggested by Ng and Perron (2001). The last three columns refer to the KSS (2003), Kruse (2011) and BBC (2004) tests. The Ng-Perron tests include an intercept, whereas the KSS, Kruse and BBC test have been applied to the de-meaned data. Superscripts * and ** mean rejection of the null hypothesis at the 10% and 5% significance levels respectively. The critical values for the Ng-Perron, Kruse and BBC tests have been taken from Ng and Perron (2001), Kruse (2011) and BBC (2004) respectively, whereas those for the KSS have been obtained by Monte Carlo simulations with 50,000 replications.

Critical Values

Significance level	MZ_α	MZ_t	*MSB*	MP_t	KSS	Kruse	BBC
5%	-8.100	-1.980	0.233	3.170	-2.907	10.170	18.400
10%	-5.700	-1.620	0.275	4.450	-2.632	8.600	16.181

Table 4: LS unit root tests results

	Break 1	Break 2	Test statistic
Czech Republic	1998:12	1999:05	-1.872
Estonia	2000:10	2002:09	-2.308
Hungary	2000:06	2003:03	-0.779
Latvia	2004:03	2006:06	-3.144
Lithuania	2002:03	2003:05	-3.683*
Poland	1999:04	1999:08	-2.146
Slovenia	2002:09	2002:12	-2.298
Slovakia	1999:01	1999:08	-2.081
EU-15	2003:07	2006:06	-3.584*

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

Table 5: Estimates of *d* in model (11) based on white noise disturbances

	With no regressors	With only intercept	With intercept and linear trend
Czech Republic	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)
Slovakia	1.019** (0.928, 1.150)	1.250 (1.179, 1.351)	1.248 (1.180, 1.344)
Slovenia	0.976** (0.868, 1.127)	1.056** (0.962, 1.185)	1.057** (0.960, 1.188)
EU-15	0.962** (0.850, 1.118)	1.235 (1.181, 1.305)	1.225 (1.173, 1.293)

Note: Superscript ** indicates cases in which a unit root (i.e. $d = 1$) cannot be rejected at the 5% level. The values in parentheses refer to the 95% confidence band.

Table 6: Estimates of *d* in model (13) based on AR(1) disturbances

	With no regressors	With only intercept	With intercept and linear trend
Czech Republic	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)
Slovakia	0.059 (0.036, 0.113)	0.268 (0.214, 0.348)	0.179 (0.120, 0.266)
Slovenia	0.000** (-0.026, 0.065)	-0.006** (-0.137, 0.198)	0.123** (-0.025, 0.268)
EU-15	-0.005** (-0.024, 0.062)	-0.034** (-0.307, 0.163)	0.065** (-0.098, 0.215)

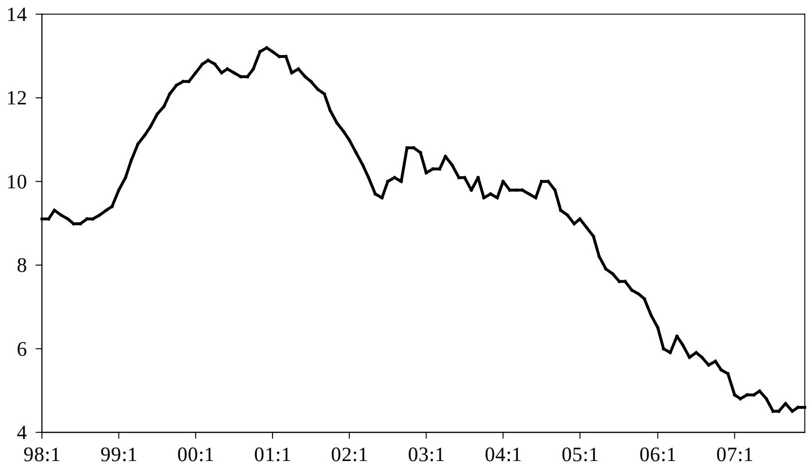
Note: Superscript ** indicates cases where stationarity (i.e. d = 0) cannot be rejected at the 5% level. The values in parentheses refer to the 95% confidence band.

Table 7: Estimates of parameters in model (13) with an intercept and AR(1) disturbances

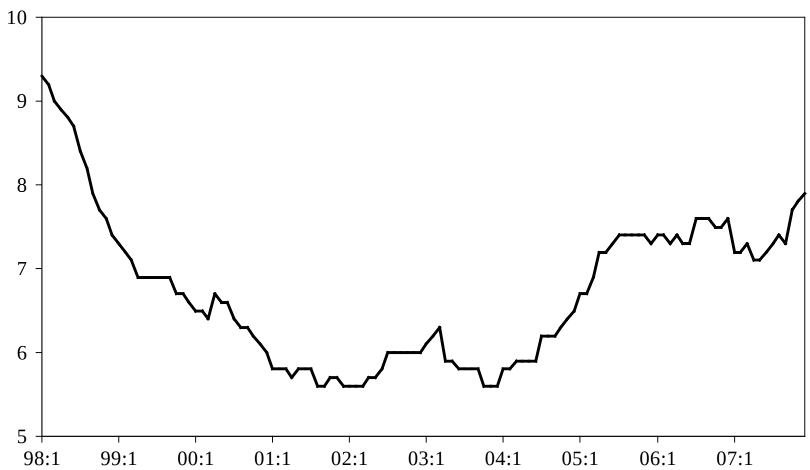
	Intercept	*d*	AR coefficient
Czech Republic	7.063	0.358	0.956
Estonia	9.229	0.281	0.979
Hungary	6.797	0.281	0.982
Latvia	11.012	-0.053	0.995
Lithuania	11.476	0.046	0.997
Poland	13.805	0.358	0.984
Slovakia	15.448	0.268	0.977
Slovenia	6.407	-0.006	0.985
EU-15	8.541	-0.034	0.995

Figure 1: Unemployment rates in the CEE countries

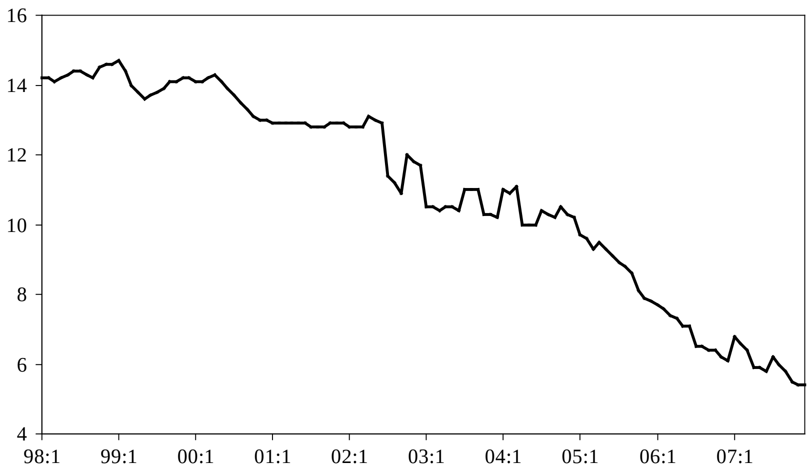
a) Czech Republic



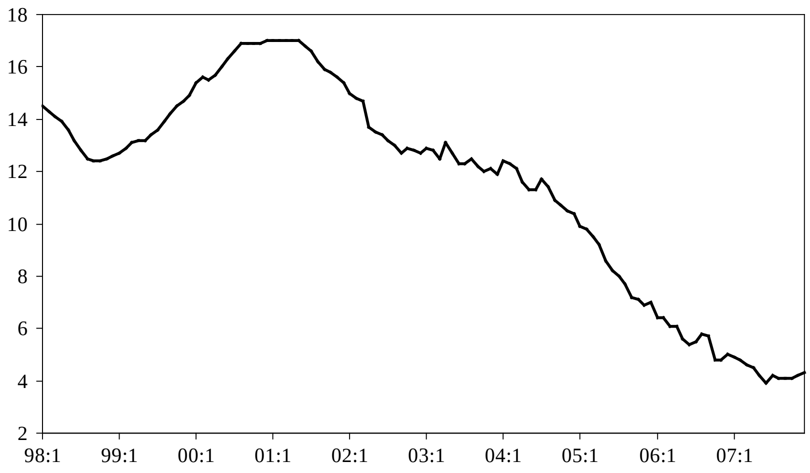
b) Estonia



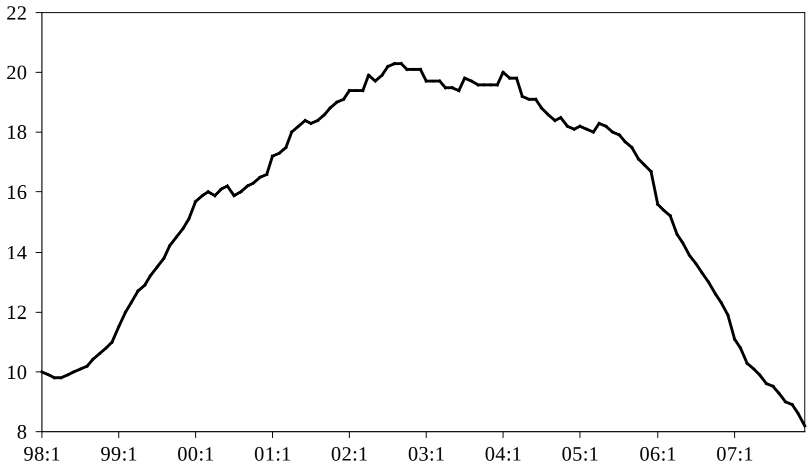
c) Hungary



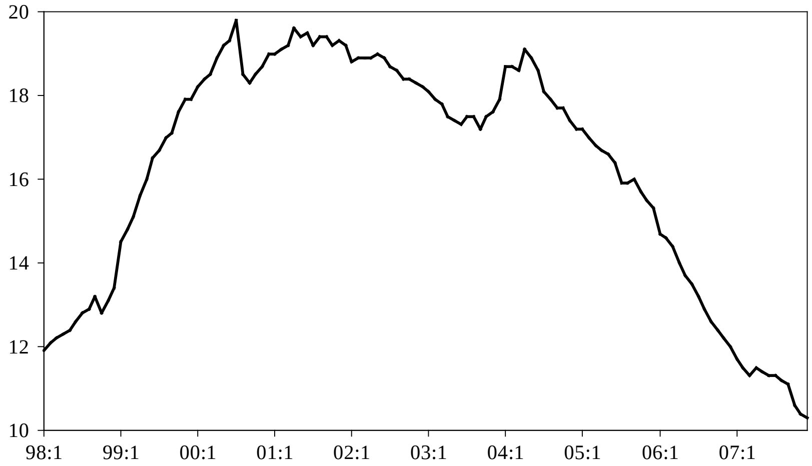
d) Latvia



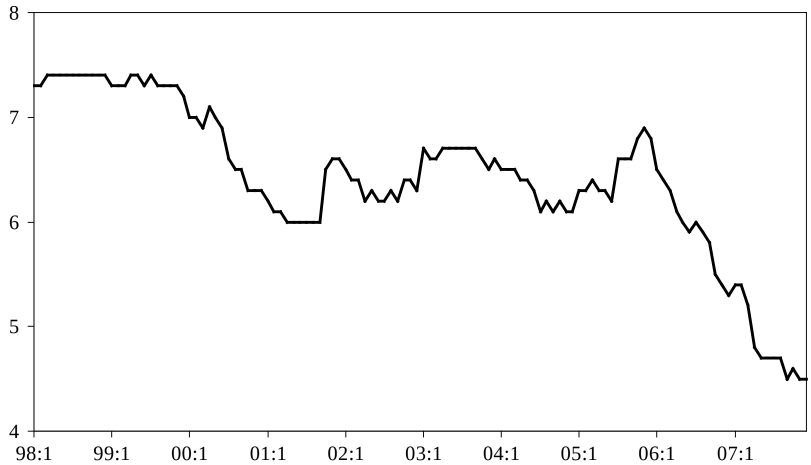
e) Lithuania



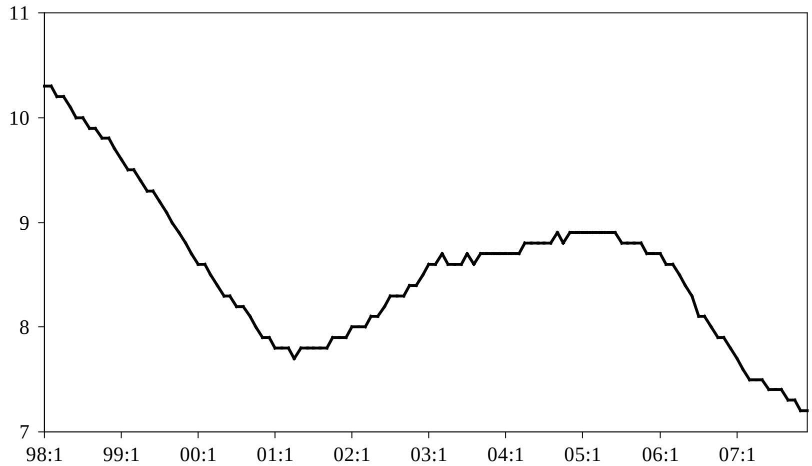
f) Poland



g) Slovakia

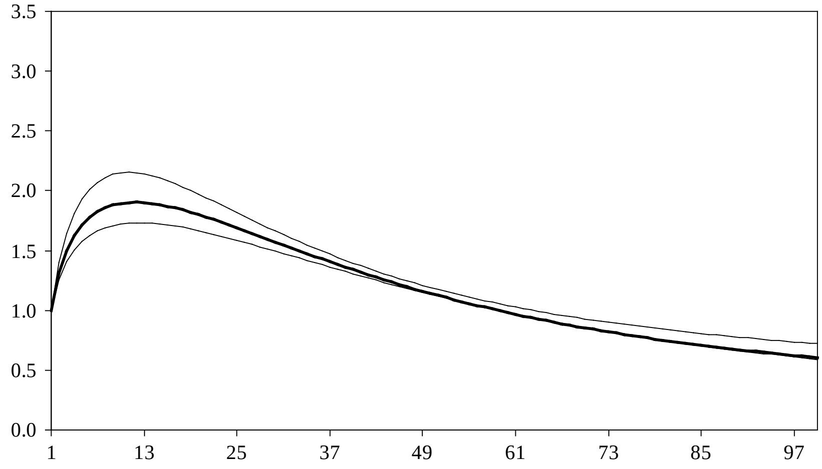


h) Slovenia

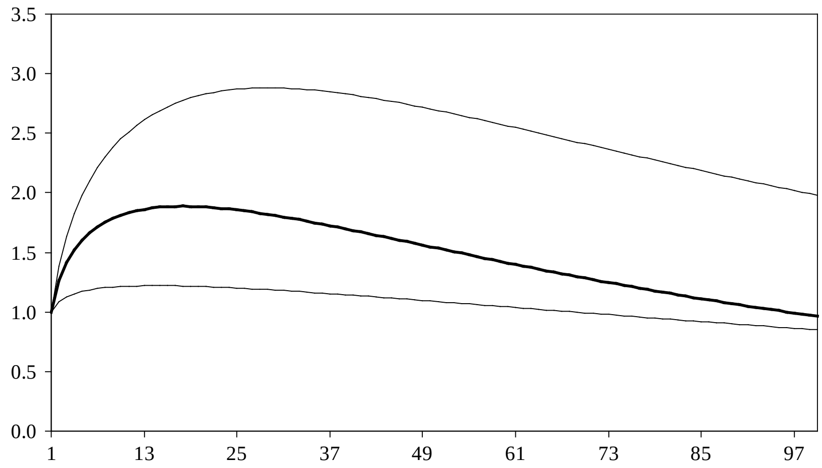


i) EU-15

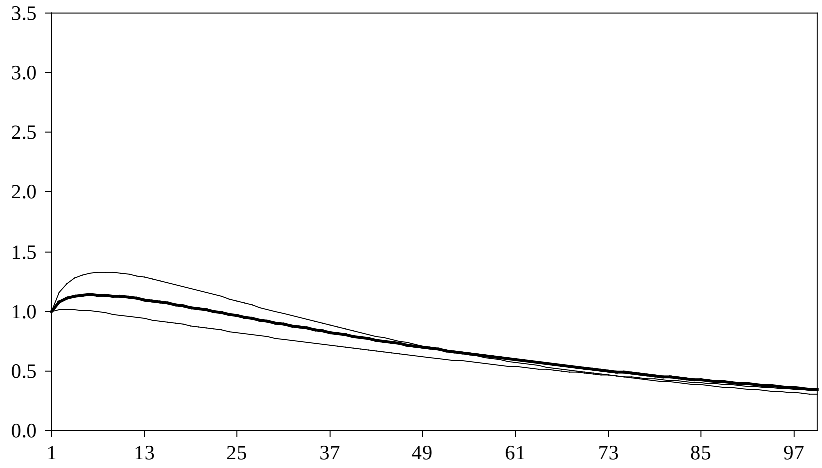
Figure 2: Impulse response functions



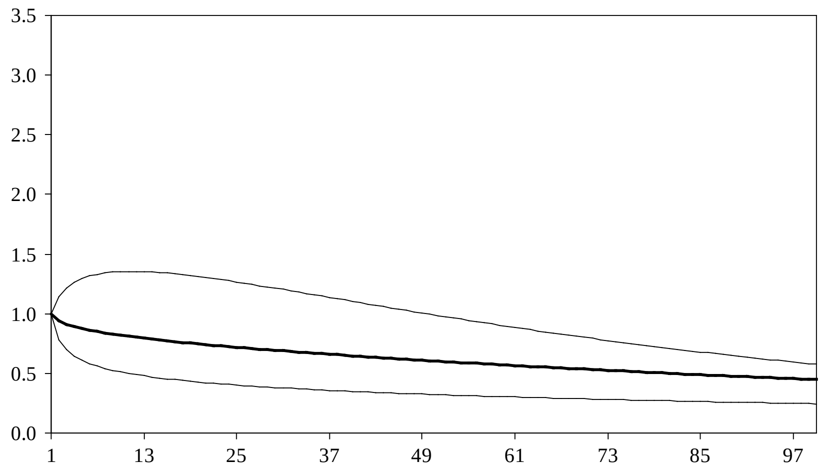
a) Czech Republic



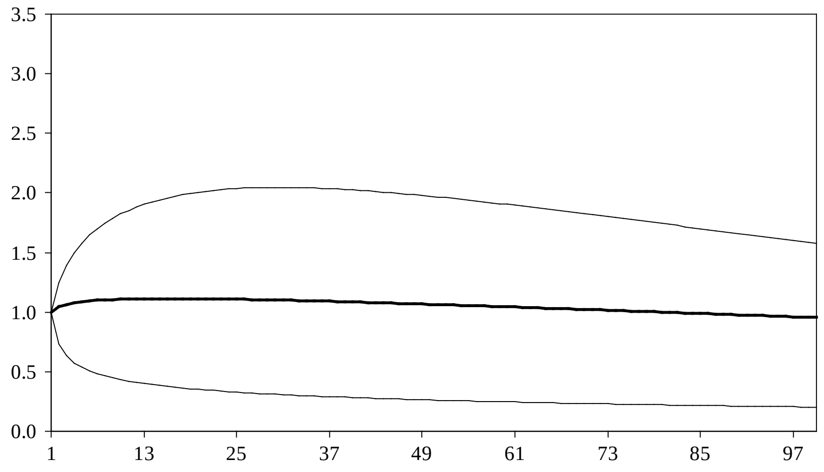
b) Estonia



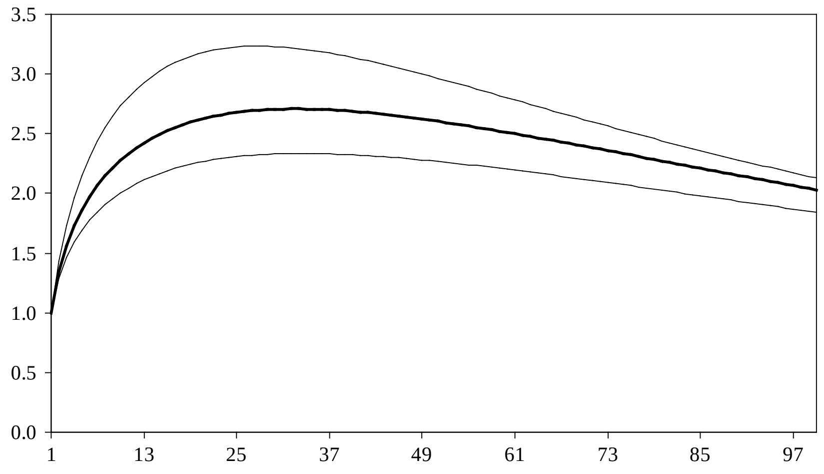
c) Hungary



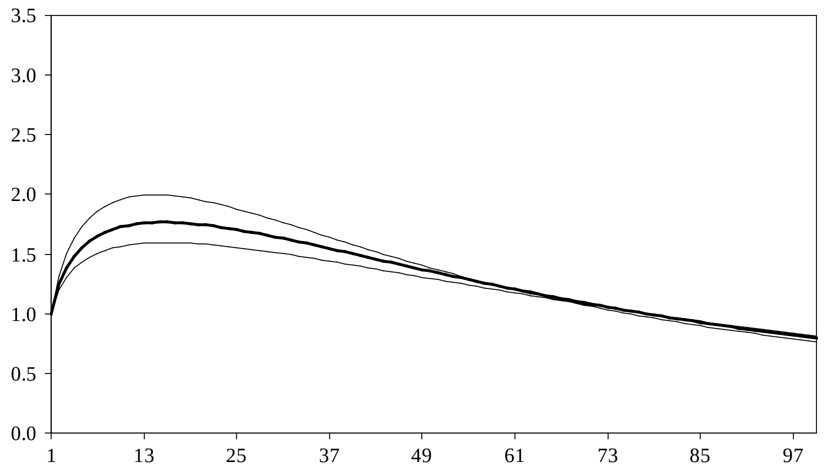
d) Latvia



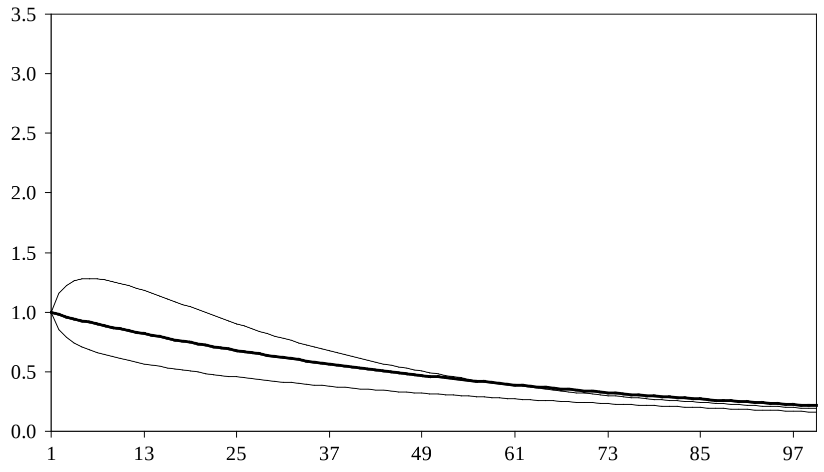
e) Lithuania



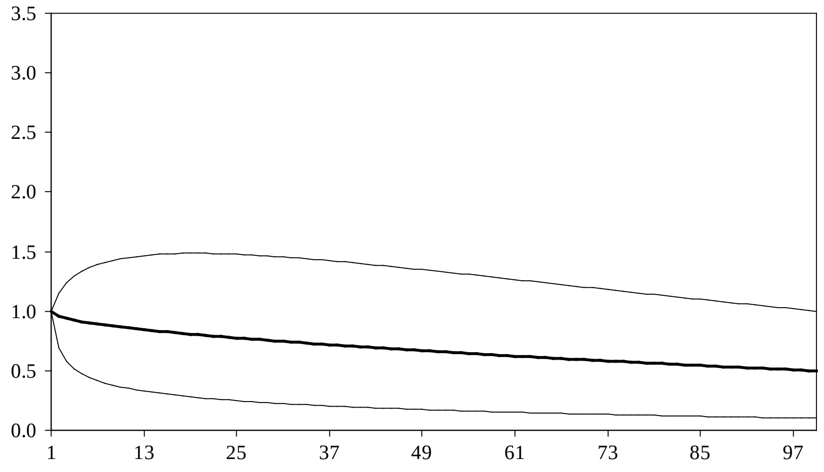
f) Poland



g) Slovakia



h) Slovenia



i) EU-15