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Chapter 5

EVALUATING PERSISTENCE IN THE UNEMPLOYMENT RATE OF EMERGING EUROPEAN ECONOMIES

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ABSTRACT

Alternative unemployment theories imply different dynamic characteristics of the unemployment rate time-series. Therefore, time-series econometric methods provide a methodological framework for testing the validity of the two most important theories of unemployment: the theory of unemployment hysteresis and the theory of the natural rate of unemployment. Discrimination between the two theories is based on the empirical assessment of whether unexpected random shocks have a long-lasting effect on unemployment.

The purpose of this paper is to evaluate the persistence of the unemployment rate in the following emerging European countries: Slovenia, Slovakia, the Czech Republic, Poland, Hungary, Cyprus, Malta, Estonia, Latvia and Lithuania. The unemployment rate in the EU15 is also analyzed. Monthly time series are collected from 2004 when these countries joined the EU. The sample ends in mid-2015.

The econometric analysis has three steps. First, ordinary unit-root tests are employed, showing that almost all series are non-stationary. Second, the Lee-Strazicich unit-root test designed to handle up to two structural breaks is applied, providing results opposite to those first reached. Third, given that a linear specification may be inadequate to capture the true dynamics in the unemployment rate, the Markov-switching autoregressive model is used. The model outperforms a standard linear specification in several economies.

Persistence in the unemployment rate was found to be at a relatively high level, in some cases exceeding the degree of persistence in EU15. No unique pattern was found in respect to the level of persistence associated with either a rising or a falling trend in the unemployment rate.

Keywords: unemployment rate, persistence, unit-root, structural break

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INTRODUCTION

Unemployment is one of the key variables for implementing economic policy. This stems from the significant impact unemployment has on macroeconomic variables, primarily inflation. Evaluating the persistence of unemployment may provide relevant information for policy makers to understand the path and dynamics of important macroeconomic variables.

Time-series econometric methods provide a methodological framework for testing the validity of the two most important theories of unemployment: the theory of unemployment hysteresis and the theory of the natural rate of unemployment. The Blanchard-Summers (Blanchard and Summers (1987) and Barro (1988)) theory of unemployment hysteresis implies an extremely high level of persistence, so that influences of unexpected random shocks to unemployment have long-lasting effects. Using econometric terminology, the existence of a unit-root in the unemployment rate would support the theory of unemployment hysteresis. The Friedman-Phelps (Friedman (1968) and Phelps (1967, 1968)) natural rate of unemployment theory is based on the assumption that in the long-run the unemployment rate is determined by macroeconomic fundamentals, so that unexpected shocks only have temporary influence. Hence, the unemployment rate should fluctuate around a stationary equilibrium level, which may have a deterministic trend. For the natural rate of unemployment theory to be accepted as empirically valid, no unit-roots are supposed to be found in the unemployment rate time-series.

Naturally, unit-root tests emerge as the first statistical tool useful in making discrimination between the two competing theories. However, these tests cannot properly take into account several features of unemployment frequently found in empirical papers. Non-linear behavior and structural break presence, for example, represent important characteristics of this time-series. Therefore, modified unit-root tests that control for one or two structural breaks are often implemented in applied work. Also, different models designed to deal with specific aspects of non-linear dynamics are also employed.

The purpose of this paper is to evaluate the persistence of the unemployment rate in the following emerging European countries: Slovenia, Slovakia, the Czech Republic, Poland, Hungary, Cyprus, Malta, Estonia, Latvia and Lithuania. The unemployment rate in the EU15 is also analyzed. Monthly time series are considered over the period: January, 2004 – July 2015. Our sample begins in 2004, when the selected countries acceded to the EU. Over the 2004-2015 period these economies were struck by several economic shocks, giving rise to the question of how the unemployment rate reacted to them.

Econometric analysis is conducted in three steps. First, a set of ordinary unit-root tests is employed, showing that almost all series are non-stationary. Second, the Lee-Strazicich unit-root test designed to handle up to two structural breaks is applied, providing results opposite to those first reached. In fact, stationarity around the broken trend was detected as the dominant feature of most time-series considered. Third, linear specification cannot explain the smooth adjustments of the unemployment rate to the shocks, which is a feature described in literature (for example: Cuestas and Ordonez (2011), Fosten and Ghoshray (2011), Ghoshray and Stamatogiannis (2015)). Hence, models with time-varying parameters seem preferable for describing changes due to frequent and huge shocks. We use the Markov-switching autoregressive model (Hamilton (1989, 1990)). This specification assumes that the mean, variability, and persistence of the unemployment rate change randomly across different

regimes. The superiority of this specification over the standard linear autoregressive model was confirmed for several economies.

The contribution of this paper is twofold. First, it includes the recent period, enabling the assessment of the influence the 2008-2009 crisis has had on the unemployment rate dynamics. Second, our econometric approach combines frequently used techniques with some of the methods mostly neglected in this type of empirical investigation for emerging European countries.

The rest of the paper is organized as follows. Section 2 reviews the recent empirical literature that econometrically tested the two competing unemployment theories. The results of unit-root testing in our sample are given in Section 3, while Section 4 describes the results of the Markov-switching autoregressive models. Concluding remarks are summarized in Section 5.

2. LITERATURE REVIEW

The empirical validity of the unemployment hysteresis hypothesis was assessed for a number of countries and regions. The methodological framework was used according to the development and achievements in time-series and panel econometrics. Contrary to the literature for developed economies, empirical investigation for emerging economies, including those in Europe, has not been performed often.

Leon-Ledesma and McAdam (2004) has quantified the degree of persistence in 12 countries from Central and Eastern Europe (including Croatia and Russia). Results were benchmarked against the EU. Data are considered over the period of early transition: 1992-2001. Standard univariate and panel unit-root tests were employed, along with the unit-root test that allows for one break. The latter test rejected the unemployment hysteresis hypothesis. To take into account the multiple equilibrium patterns in the unemployment rate, the Markov switching regression model was estimating, suggesting the presence of a high and low unemployment equilibrium towards which the economy fluctuates when large shocks occurred. For almost all economies the speed of adjustment was estimated to be greater than in the EU.

In Camarero, Carrion-i-Silvestre and Tamarit (2005, 2008) 9 European economies were considered that joined the EU in 2004. The unemployment rate time-series are analyzed for the time span of 1991-2003. The hysteresis hypothesis is tested versus the natural rate hypothesis on unemployment using univariate and panel unit-root tests that account for the presence of level shifts. The results rejected the hysteresis hypothesis and indicated up to four structural breaks that can be explained by institutional changes due to the implementation of market-oriented reforms. The estimated degree of persistence in unemployment differs significantly across countries, reflecting the stage reached in the transition process and the institutional set-up of the labor market.

Cuestas and Ordonez (2011) investigated the unemployment rate dynamics of 8 emerging European economies over the period 1998-2007. A nonlinear unit-root test was implemented showing that in five countries unemployment is a stationary process with highly persistent structural changes. Additionally, evidence was presented showing the possibility of a time varying equilibrium unemployment rate for four countries that shared a common nonlinear

component. The same data set is analyzed in Cuestas, Gil-Alana and Staehr (2011) along with the unemployment rate for EU15. The econometric methodology was based on unit-root tests that account for structural changes, non-linearities and fractionally integrated alternatives. The model that assumes fractional integration showed that the unemployment rate does not contain a unit-root in any of the 8 economies. However, the level of persistence is estimated to be high, although it differs substantially among countries in the sample. Findings in this paper indicate that a future crisis would have an effect on the unemployment rates in some of the Central and Eastern European economies similar in magnitude to that experienced by the EU-15.

Furuoka (2015) examined the level of unemployment persistence in Estonia using annual data from 1993 to 2011 for five different regions. Panel data methods are applied revealing that data are well described as being mean-reverting processes. Thus, the natural rate in unemployment hypothesis is empirically supported by these data in Estonia.

3. EMPIRICAL RESULTS OF UNIT-ROOT TESTING

Our data set comprises monthly observations on the unemployment rate for the following emerging European countries: Slovenia, Slovakia, the Czech Republic, Poland, Hungary, Cyprus, Malta, Estonia, Latvia and Lithuania. The unemployment rate in EU15 is also taken into account. All data cover the sample period from January, 2004 to July, 2015 (139 observations). Data are collected from EUROSTAT. Empirical results are obtained by Oxmetrics9.1, RATS and EViews9.

Data are depicted in Figure 1. We may notice that series exhibit a changing trend suggesting that the sample covers intervals of both a decrease and an increase in the unemployment rate. In order to find out if the trend is of a stochastic or deterministic nature we apply several unit-root tests with the results given in Table 1. It is evident that the unemployment rates are unit-root processes in all economies. Thus, persistence is estimated to be extremely high. For three countries (Poland, Latvia and Lithuania) some of the tests even implied two unit-roots. However, we argue that such a result is probably due to unaccounted structural breaks.

To capture unemployment dynamics in a more accurate way, unit-root tests should explicitly take into account the possibility that structural breaks exist. Thus, we further calculated the values of the Lee-Strazicich (LS) unit-root test (Lee and Strazicich, 2003), widely used to incorporate up to two structural breaks. The test that assumes changes in both intercept and slope of the deterministic trend function is applied. Results are reported in Table 2. Non-stationarity is confirmed only for the unemployment rate in Cyprus and Hungary. In other countries, including the EU-15, we found strong evidence of stationary movements that follow the broken deterministic trend component. One structural break was identified within the second half of 2008 in almost all cases. This finding indicates the significant influence the start of the Great recession has had on the unemployment rates in most of the countries analysed.

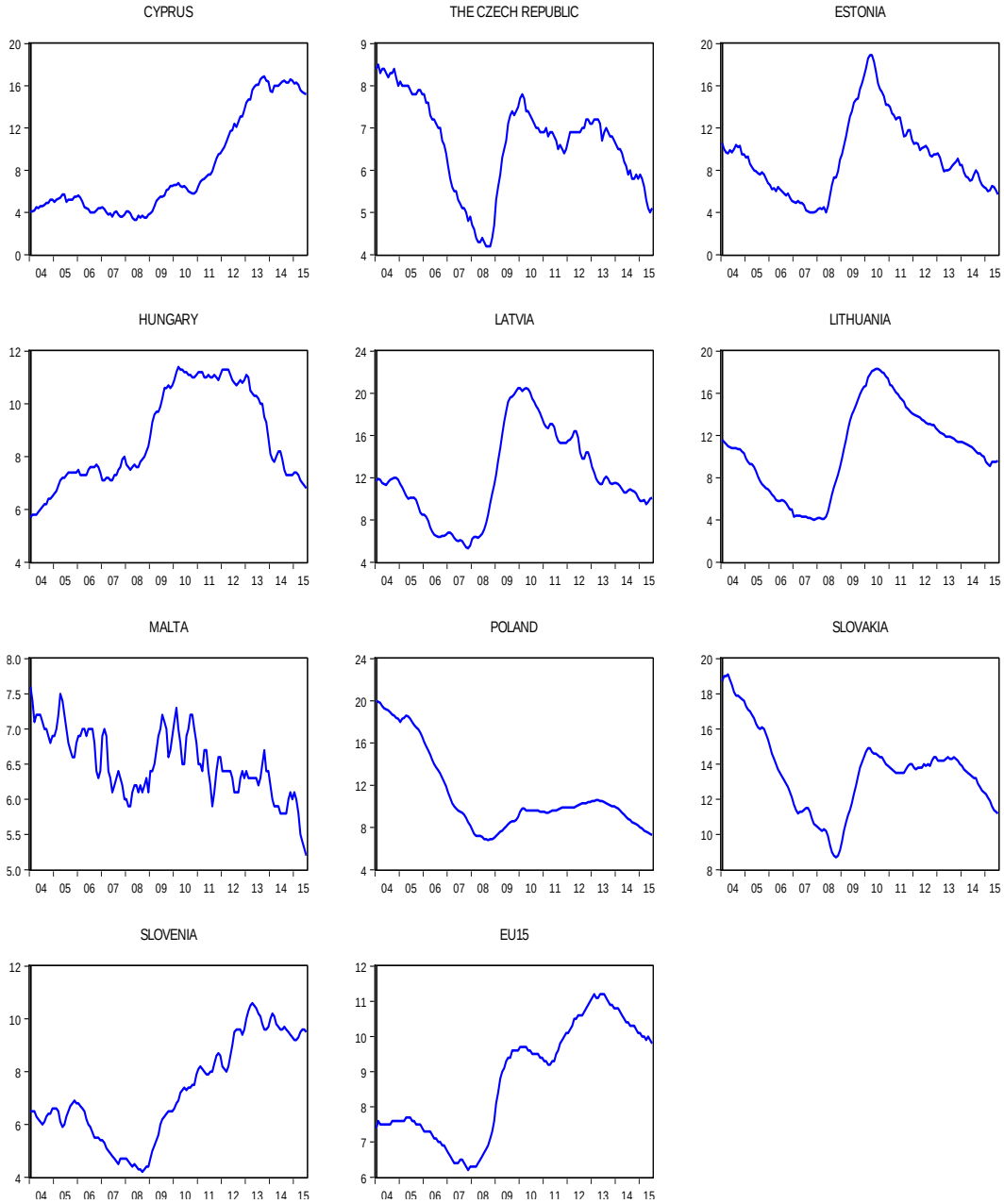

Figure 1. The unemployment rate in select economies.

The identified breaks actually show that huge shocks have a significant impact on the unemployment rate. Therefore, short-lived temporary shocks, along with a few permanent shocks described by structural breaks, seem like a plausible explanation for the unemployment rate in most of the emerging European economies. In addition, this result implies that unemployment reverts to its constant or average level upon a sudden change due to a break. This clearly rejects the unemployment hysteresis hypothesis in the following countries: Slovenia, Slovakia, the Czech Republic, Poland, Malta, Estonia, Latvia and

Lithuania Contrary to this, the hypothesis is accepted as empirically valid for Cyprus and Hungary.

Table1. Results of unit-root testing

Country	Test for unit-root in	ADF	Number of lags	Unit-root	KPSS	Unit-root	ERS	Unit-root
Cyprus	Level	0.27	1	Yes	1.11	Yes	1.18	Yes
	1st difference	-8.33	0	No	0.31	No	-7.27	No
The Czech Republic	Level	-1.88	2	Yes	0.76	Yes	-0.85	Yes
	1st difference	-4.90	1	No	0.30	No	-3.87	No
Estonia	Level	-1.21	1	Yes	1.06	Yes	-1.22	Yes
	1st difference	-6.48	0	No	0.40	No	-6.33	No
Hungary	Level	-1.40	1	Yes	3.16	Yes	-0.69	Yes
	1st difference	-6.30	0	No	0.70	No	-6.32	No
Latvia	Level	-2.21	4	Yes	0.70	Yes	-2.21	Yes
	1st difference	-2.63	3	Yes	0.27	No	-2.64	No
	2nd difference	-12.02	2	No	-	-	-	-
Lithuania	Level	-2.24	2	Yes	1.53	Yes	-2.21	Yes
	1st difference	-2.32	1	Yes	0.74	Yes	-2.09	No
	2nd difference	-18.73	0	No	0.04	No	-	No
Malta	Level	-1.51	4	Yes	1.46	Yes	0.91	Yes
	1st difference	-9.21	3	No	0.06	No	-6.02	No
Poland	Level	-2.47	4	Yes	1.56	Yes	-0.26	Yes
	1st difference	-2.39	3	Yes	0.83	Yes	-2.19	No
	2nd difference	-10.19	2	No	0.04	No	-	-
Slovakia	Level	-2.85	1	Yes	0.31	No	-0.26	Yes
	1st difference	-4.13	0	No	-	-	-2.19	No
Slovenia	Level	-0.79	1	Yes	0.99	Yes	-0.65	Yes
	1st difference	-5.83	0	No	0.28	No	-5.08	No
EU-15	Level	-1.40	2	Yes	1.08	Yes	-1.02	Yes
	1st difference	-3.13	1	No	0.14	No	-3.37	No

Note: The model with a constant is used. The 5% critical values are -2.88, 0.46 and -1.94 respectively for the ADF, the KPSS and the ERS test. The number of lags refers to a number of correction elements included in the application of the ADF and the ERS test. The truncation parameter in calculating the Newey-West correction for KPSS test is either set to 8 or 9, or it corresponds to the number of corrections in the ADF test.

Table 2. Results of the LS unit-root testing that accounts for up to two structural breaks

Country	Number of lags	Dates of breaks	LM test statistics
Cyprus	14	-	-4.42
The Czech Republic	13	October, 2008. June, 2011.	-5.98*
Estonia	13	September, 2006. November, 2009.	-5.69*
Hungary	18	-	-4.90

Country	Number of lags	Dates of breaks	LM test statistics
Latvia	17	August, 2008. May, 2012.	-6.39*
Lithuania	15	September, 2006. December, 2009.	-7.64*
Malta	15	November, 2008. September, 2011.	-4.99**
Poland	12	November, 2006. February, 2011.	-7.39*
Slovakia	18	November, 2008. November, 2011.	-5.81*
Slovenia	18	December, 2007. August, 2008.	-5.27*
EU15	13	September, 2008. February, 2012.	-5.82*

Note: * and ** respectively denote the values of the test-statistics that are less than the critical values for the significance level of 5% and 10%.

4. MODELLING THE UNEMPLOYMENT RATE DYNAMICS

Some empirical results for OECD countries (for example: Fosten and Ghoshray (2011) and Ghoshray and Stamatogiannis (2015)) and economies in the early phase of transition (Leon-Ledesma and McAdam, 2004) indicate that the unemployment rate dynamics is characterized by at least two different regimes during which it supports either hysteresis or natural rate hypothesis of unemployment. Such a behaviour cannot be discovered by the unit-root tests applied above. The Markov-switching (MS) model appears as the relevant framework, because it can associate different degrees of persistence, mean and variability in the unemployment rate with different regimes over time. We have found only one paper that addressed this approach in quantifying the degree of persistence in emerging European countries (Leon-Ledesma and McAdam, 2004).

We will undertake the estimation of MS specification for all data except for those countries (Hungary and Cyprus) where all unit-root tests indicate non-stationarity of the unemployment rate.

The basic idea of the MS model, upon which empirical results will be provided, will briefly be reviewed. The baseline method in time-series analysis to measure the persistence in time- series x_t is the sum of autoregressive coefficients, $\sum_{i=1}^{p}\phi_i$, from the autoregressive model of order p, $x_t = \alpha_0 + \sum_{i=1}^{p}\phi_i x_{t-i} + e_t$. This can be rewritten as: $x_t = \alpha_0 + \rho x_{t-1} + \sum_{i=1}^{(p-1)}\delta_i \Delta x_{t-i} + e_t$, so that the parameter $\rho = \sum_{i=1}^{p}\phi_i$ contains information about the sum of autoregressive parameters and thus provides a measure of persistence in the unemployment rate. The error term, e_t, is Gaussian white noise.

This specification can be modified in a number of different ways to take account of possible regime changes and nonlinearity in a given time series. To allow for changes in some parameters we employ the Markov-switching autoregressive model assuming that mean, variability and persistence may differ between two regimes. The relevant specification is of the following form (Hamilton (1989, 1990)):

$$x_t = (\alpha_0 + \alpha_1 S_t) + (\rho + \rho_1 S_t)x_{t-1} + \delta_1 \Delta x_{t-1} + \ldots + \delta_{p-1} \Delta x_{t-p+1} + (h_0 + h_1 S_t)e_t \quad (4.1)$$

S_t is the unobserved random variable that follows a Markov chain defined by transition probabilities between two states. The full matrix of transition probabilities for two states reads as follows:

State at *t+1*	Condition at *t*	
	$S_t=0$	$S_t=1$
$S_{t+1}=0$	$q=p_{0/0}$	$f=p_{0/1}$
$S_{t+1}=1$	$p_{1/0}$	$P_{1/1}$

Shifts of the economy from state 0 to state 1 are governed by the introduced random variable S_t. Under this specification we have two different regimes: regime 0 (i.e., S_t =0) and regime 1 (i.e., S_t =1). The parameters α_1, ρ_1, h_1 capture the changes in the mean of the unemployment rate, the persistence of a shock to the unemployment rate and the variance during regime 1 relative to regime 0.

Satisfactory models were estimated for all emerging economies and the EU-15. The results are given in Tables 4.1-4.7 and relevant graphs are depicted in Figures 4.1 - 4.6. Since the results are similar for the three Baltic countries, only the results for Estonia are presented.

The Czech Republic

The two-state MS model fits well to the dynamics of the unemployment rate in the Czech Republic. Two different persistence regimes have been detected. Regime 0 has an extremely high persistence characterized by the estimated magnitude of $\hat{\rho} = 0.994$. This is also a regime of a lower mean level. Regime 1 is found to have a smaller persistence: the estimate is 0.839. During regime 1 the unemployment rate exhibited a higher mean value. Statistically, persistence does not differ from 1 in regime 0, suggesting unit-root presence. Therefore, this specification explains two statistically different regimes in the unemployment persistence. Economic implications also vary across the two regimes.

The probability *q* of remaining in the regime of higher persistence, while being in that regime is 0.98. The probability *f* of switching from the regime of lower to the regime of higher persistence is small and is equal to 0.02, implying that the probability of staying in the regime of lower persistence is also high, 0.98. The economy remains in the regime of extremely high persistence in unemployment 57% of the time, while the remaining 43% is associated with the regime of lower persistence in unemployment. The average duration of the regime of high persistence is 38 months, while the average duration of the regime of lower persistence is 57 months.

A visual inspection of the regimes, from Figure 2, indicates that the regime of extremely high persistence (regime 0) is closely related to a strong downward trend in the unemployment rate. The regime of lower persistence is estimated for time intervals during which the unemployment rate exhibited either an upward or a mild downward trend. We may conclude that there is an asymmetric reaction of unemployment to positive or negative shocks. In general, persistence is higher when strong negative shocks occur.

Table 3. Estimated model for the Czech Republic

Parameter	α_0	$(\alpha_0+\alpha_1)$	ρ	$(\rho+\rho_1)$	h_0	Q	F
Estimate	-0.002	1.12	0.994	0.839	0.12	0.98	0.02
p-value	0.98	0.00	0.00	0.00	0.00	0.00	0.36

Parameter	δ_1	δ_5	δ_7
Estimate	0.17	0.20	0.12
p-value	0.09	0.02	0.07

$Linearity\ test:\ \chi^2_4 = 20.29(0.00);\ Box-Pierce\ \ Q(36)\ \ \chi^2_{36} = 24.91(0.92),$
$ARCH\ 1\ \ F = 0.84(0.36);\ Normality \chi^2_2 = 0.60(0.74)$

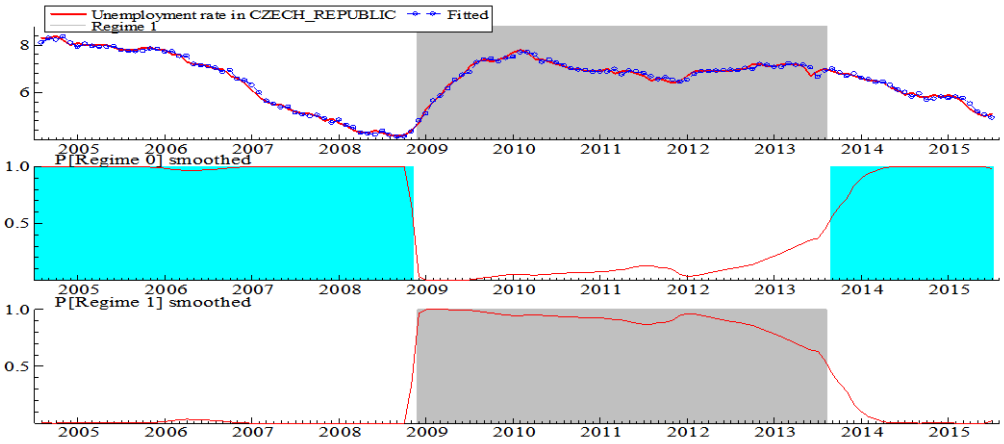

Figure 2. Two regimes of persistence in the Czech Republic.

Estonia

The two-state MS model performs well for the unemployment rate in Estonia. Regime 0 has a smaller unemployment persistence, estimated to be 0.933. Regime 1 is described as having a slightly higher persistence (the estimate is 0.961). These measures of persistence differ significantly at the 10% level (according to the Wald test), but they imply stationarity in both cases. The average duration of regime 0 is about 10 months, taking up 61% of the sample. The remaining 39% belongs to regime 1, lasting 7 months on average (Figure 3). The period of up to mid-2010 is split almost equally between the two regimes, such that the regime of smaller persistence covers a strong downward trend, while the regime of higher

persistence describes a rapid growth in the unemployment rate over the period June 2008 - April 2010. After that, switches between regimes occurred more often, but sharp decreases in unemployment rate were again closely related to a lower level of persistence.

The probability of staying in the regime of lower persistence when already in that regime is q=0.90, while the probability of staying in the regime of higher persistence while being in that regime is 0.83 (1-f).

Similar results were found for Latvia and Lithuania. In the case of Latvia, one of the two regimes was estimated to have a unit-root in unemployment rate, but it covers only one-third of the sample.

Table 4. Estimated model for Estonia

Parameter	α_0	$(\alpha_0+\alpha_1)$	ρ	$(\rho+\rho_1)$	h_0	Q	F
Estimate	0.36	0.67	0.933	0.961	0.26	0.90	0.17
p-value	0.00	0.00	0.00	0.00	0.00	0.00	0.05

Parameter	δ_1	δ_5	δ_8
Estimate	0.20	0.15	0.34
p-value	0.02	0.01	0.00

$Linearity\ test:\ \chi^2_4 = 12.89(0.01); Box-Pierce\ \ Q(36)\ \chi^2_{36} = 42.10(0.22),$
$ARCH\ 1\ \ F = 0.57(0.45); Normality \chi^2_2 = 0.98(0.61)$

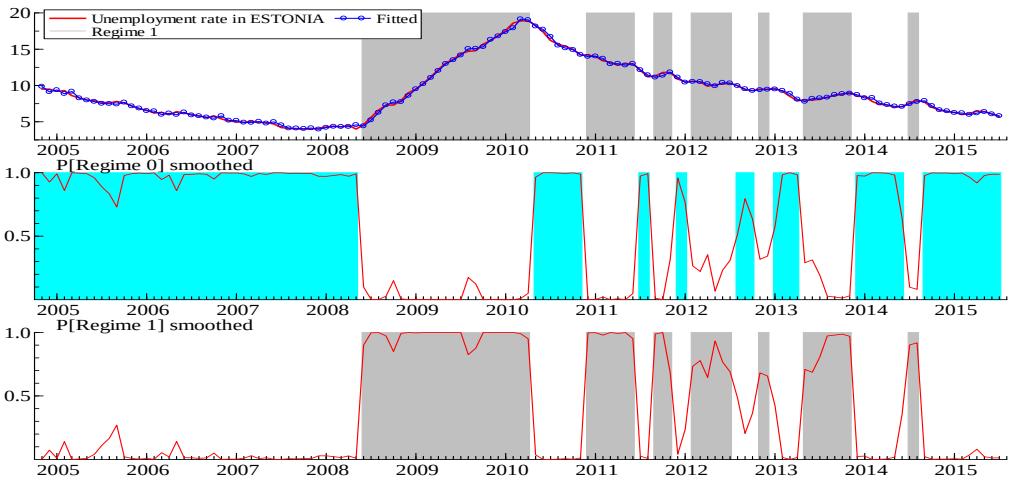

Figure 3. Two regimes of persistence in Estonia.

Malta

The estimated two-state MS model for the unemployment rate in Malta reveals specific properties of this time-series. Regime 0 is found to have a lower degree of persistence estimated at 0.95. Regime 1 is estimated to be of a higher persistence that suggests unit-root

presence (the estimate is 1). The probability q of staying in the regime of lower persistence, while being in that regime is 0.87. The probability 1-f of remaining in the regime of higher persistence is low, 0.09.

The economy spent about 87% of the time in the lower persistence regime 0. Its average duration was 7 months. The remaining 13% is described by a unit-root regime 1 with an average duration of 1.13 month. Unit-root behaviour is short-lived. Due to transitory shocks, persistence has a tendency to increase, but it rapidly returns to its mean value (Figure 4).

Table 5. Estimated model for Malta

Parameter	α_0	$(\alpha_0+\alpha_1)$	ρ	$(\rho+\rho_1)$	h_0	(h_0+h_1)	Q	F
Estimate	0.26	0.19	0.953	1.006	0.13	0.006	0.87	0.91
p-value	0.19	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Parameter	δ_1	δ_2	δ_3	δ_4	δ_5
Estimate	0.42	0.26	-0.54	-0.18	0.43
p-value	0.00	0.00	0.00	0.00	0.00

$Linearity\ test:\ \chi^2_5 = 31.8{,}5(0.00);\ Box-Pierce\ \ Q(36)\ \ \chi^2_{36} = 47.06(0.10),$

$ARCH\ 1\ \ F = 0.02(0.87);\ Normality \chi^2_2 = 0.51(0.78)$

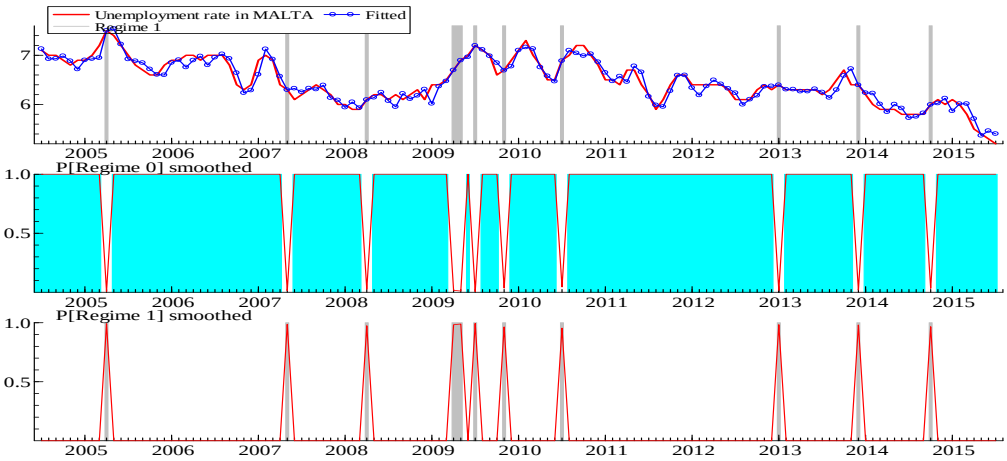

Figure 4. Two regimes of persistence in Malta.

Slovenia

The estimated two-state MS model performs statistically well. Regime 0 has a smaller persistence, estimated to be 0.992. Regime 1 is described as having a higher persistence (the estimate is 1.025). Unit-root presence was statistically found in regime 0 even showing mild explosive behaviour in regime 1. The average duration of regime 0 is about 10 months, covering 85% of the sample. The rest of the sample is associated with regime 1 that on average lasts 1.9 months (Figure 5). We may notice that mild explosive behaviour is

displayed over short subperiods of substantial increase in the unemployment rate. The probability of staying in the regime of unit-root persistence, when already in that regime is q=0.89. The probability of staying in the mild explosive regime while being in that regime is lower (0.44).

These results indicate an extremely high unemployment persistence in Slovenia that is captured either by the unit or the small explosive root.

Table 6. Estimated model for Slovenia

Parameter	α_0	ρ	$(\rho + \rho_1)$	h_0	Q	f
Estimate	0.03	0.992	1.025	0.09	0.89	0.56
p-value	0.51	0.00	0.00	0.00	0.00	0.01

Parameter	δ_1	δ_8
Estimate	0.48	0.12
p-value	0.00	0.04

Linearity test : $\chi^2_3 = 11.43(0.01)$; *Box – Pierce* $Q(36)$ $\chi^2_{36} = 34.49(0.54)$, *ARCH* 1 $F = 0.20(0.66)$; *Normality* $\chi^2_2 = 4.79(0.09)$. *Model contains two impulse dummy variables for the following months : January, 2012 and April, 2015.*

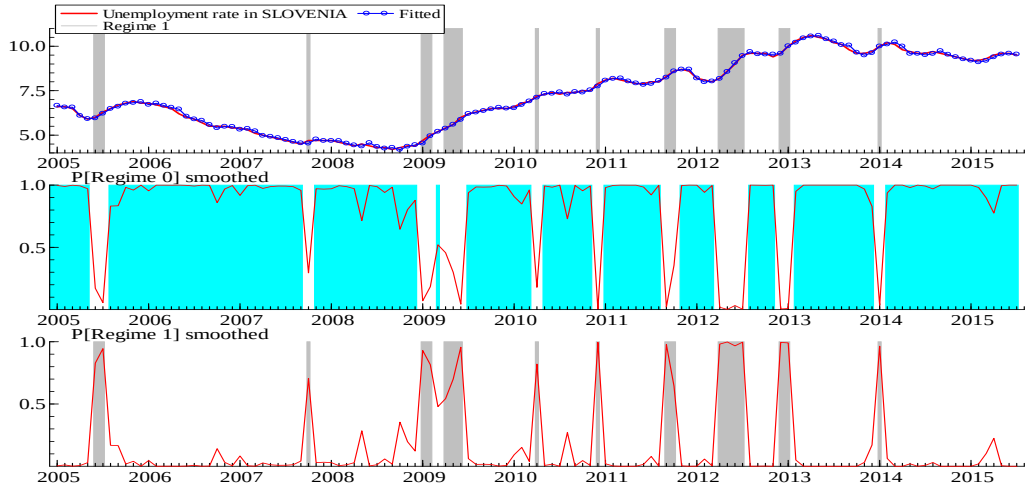

Figure 5. Two regimes of persistence in Slovenia.

Slovakia

Again the two-state MS model fits well with the changes to the unemployment rate. Regime 0 is characterized by the persistence estimate of 1.067. Regime 1 has a persistence estimate of 0.975. Regime 0 describes mild explosive behaviour in the unemployment rate associated with its lower mean level. In fact, as depicted in Figure 6, this regime is extracted

only during a systematic decrease in the unemployment rate at 16% of the sample and thus revealing the lasting impact of systematic negative shocks. Regime 1 implies stationarity of the unemployment rate during most of the sample, 84%. The average duration of the higher persistence regime is about 3 months, while the average duration of the lower persistence regime is 15 months.

The probability q of remaining in the regime of higher persistence, while being in that regime is 0.63. The probability f of switching from the regime of lower to the regime of higher persistence is only 0.08, meaning that the probability of staying in the regime of lower persistence is 0.92.

Table 7. Estimated model for Slovakia

Parameter	α_0	$(\alpha_0+\alpha_1)$	ρ	$(\rho+\rho_1)$	h_0	(h_0+h_1)	Q	F
Estimate	-0.91	0.33	1.067	0.975	0.04	0.12	0.63	0.08
p-value	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02

Parameter	δ_1
Estimate	0.82
p-value	0.00

$Linearity\ test:\ \chi^2_5 = 18.13(0.00);\ Box-Pierce\ \ Q(36)\ \chi^2_{36} = 41.96(0.23),$
$ARCH\ 1\ \ F = 0.53(0.47);\ Normality \chi^2_2 = 2.75(0.25)$

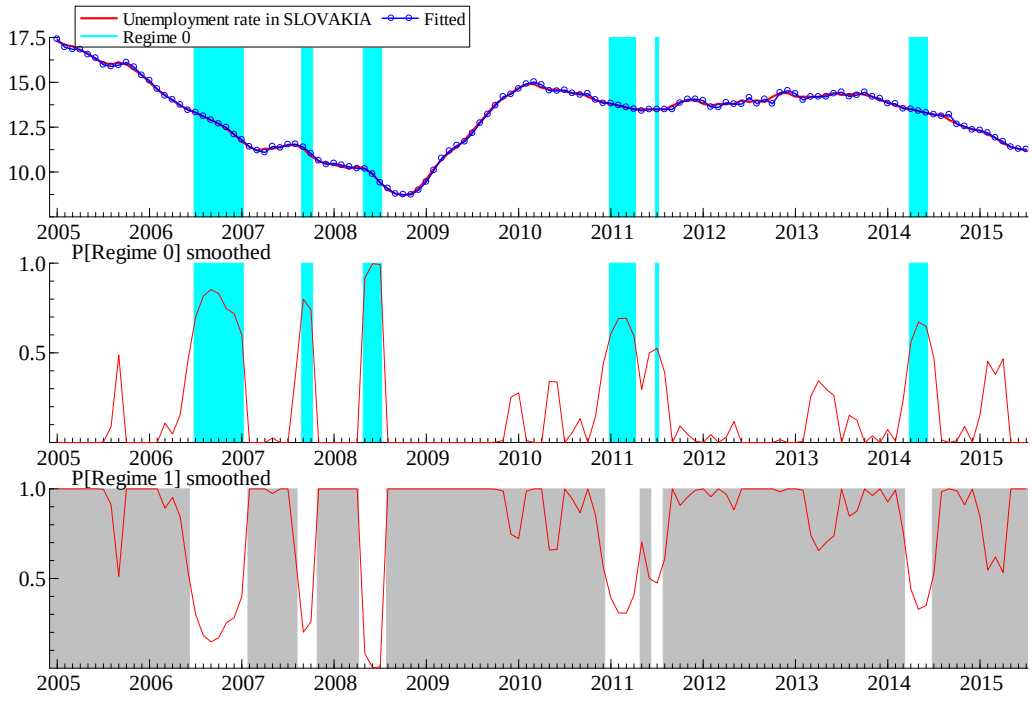

Figure 6. Two regimes of persistence in Slovakia.

Poland

The two-state MS model describes the unemployment rate dynamics in Poland well. Specifically, all parameters of the model, including short-run dynamics, were estimated for two regimes. Regime 0 was found to capture a higher persistence in unemployment with an estimate of 0.993. However, the parameter is statistically different from 1, implying stationarity. The persistence of regime 1 is quantified as 0.977. This estimate is lower than the one in regime 0, but still points to the high sensitivity of the unemployment rate to external shocks. The economy spent 75% of the time in the regime of higher persistence and 25% in the regime of lower persistence. Average durations were 3.5 and 1.2 months, respectively.

The probability q of remaining in the regime of higher persistence, while being in that regime is 0.7, about the same as the probability f of switching from the regime of lower to the regime of higher persistence. A visual presentation is omitted due to limitations of space.

Table 8. Estimated model for Poland

Parameter	α_0	$(\alpha_0+\alpha_1)$	ρ	$(\rho+\rho_1)$	h_0	(h_0+h_1)	q	F
Estimate	0.05	0.26	0.993	0.977	0.07	0.04	0.70	0.71
p-value	0.10	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Parameter	δ_1	δ_2	δ_3	δ_4	δ_7
Estimate	0.85	0.26	-0.45	0.13	0.15
p-value	0.00	0.00	0.00	0.07	0.01

Linearity test : $\chi^2_{10} = 24.05(0.01)$*; Box – Pierce* $Q(36)$ $\chi^2_{36} = 33.75(0.59)$*, ARCH* $1\ F = 0.18(0.67)$*; Normality* $\chi^2_2 = 1.08(0.58)$*, Estimates of the shorth-run parameters refer to regime 0 and they are also significant for regime 1, buth they are not reported in order to save space.*

The EU15

As a benchmark case, the two-state MS model was fitted to the unemployment rate in the EU15. Again, two different persistence regimes have been detected. Regime 0 has a higher persistence estimated to be $\hat{\rho} = 0.991$. At the same time, this is a regime with a lower mean level and variability. Regime 1 is estimated to have a lower persistence (0.942), but higher mean value and variability. In both cases degrees of persistence are significantly lower than 1. Thus, no unit-root was formally found in any of the two regimes.

The economy stays in the regime of higher persistence in unemployment 73% of the time and in the regime of relatively smaller persistence 27% of the time. The average duration of the regime of higher persistence is 33 months, while the average duration of the regime of lower persistence is 19 months. Both probabilities of staying in one regime while being in that regime are high (0.98 and 0.94 respectively for regimes 0 and 1).

We may observe a strong correlation between the regimes and the type of trend exhibited by the data. Namely, a higher persistence is found for subsamples during which unemployment tends to fall or remains relatively stable (March, 2004 - September 2008, October 2009-April 2011, July, 2013 – July, 2015). A slightly lower persistence is associated with the upward trend in the unemployment rate.

The composite unemployment rate of the EU15 shows a relatively high persistence, but not an extreme one. This time-series appears to be more sensitive to negative than to positive shocks.

Summary

We will now summarize the results of Section 4 (see also Table 10). The estimated models reveal that persistence is relatively high in the EU15. Formally, no unit-root was estimated. Similar behaviour was found for the following economies: Poland, Estonia and Lithuania.

Unit-root presence was detected within one regime in the Czech Republic (57% of the sample), Latvia (32%), Malta (13%) and Slovenia (85%). However, the unemployment rate dynamics exhibits a different pattern during the unit-root regime across different economies. For example, unit-root presence is closely associated with the fall of unemployment rate in the Czech Republic, highlighting long-lasting effects of those shocks that have reduced unemployment. The unit-root in the case of Malta is of a transitory and probably seasonal nature. The unit-root regime in Slovenia covers most of the sample and indicates a persistent response of the unemployment rate to external shocks during the entire period considered.

In the cases of Slovakia and Slovenia, mild explosive behaviour was even determined in one of the two regimes. As already discussed, the other regime in Slovenia has a unit-root. In Slovakia another regime describes stationarity. Both explosive episodes are of short duration, but they have different implications. Namely, the explosive regime in Slovakia has been estimated for subsamples during which unemployment strongly declines. Contrary to that, explosive episodes in Slovenia occurred during a systematic increase of the unemployment rate.

Table 9. Estimated model for the EU15

Parameter	α_0	$(\alpha_0+\alpha_1)$	ρ	$(\rho+\rho_1)$	h_0	(h_0+h_1)	q	F
Estimate	0.06	0.67	0.991	0.942	0.06	0.08	0.98	0.06
p-value	0.12	0.00	0.00	0.00	0.00	0.00	0.00	0.07

Parameter	δ_1
Estimate	0.18
p-value	0.03

$$Linearity\,test:\ \chi^2_5 = 33.16\,(0.00);\ Box-Pierce\ \ Q(36)\ \ \chi^2_{36} = 34.7(0.53),$$
$$ARCH\,1\ \ F = 1.78(0.19);\ Normality\,\chi^2_2 = 3.04(0.21)$$

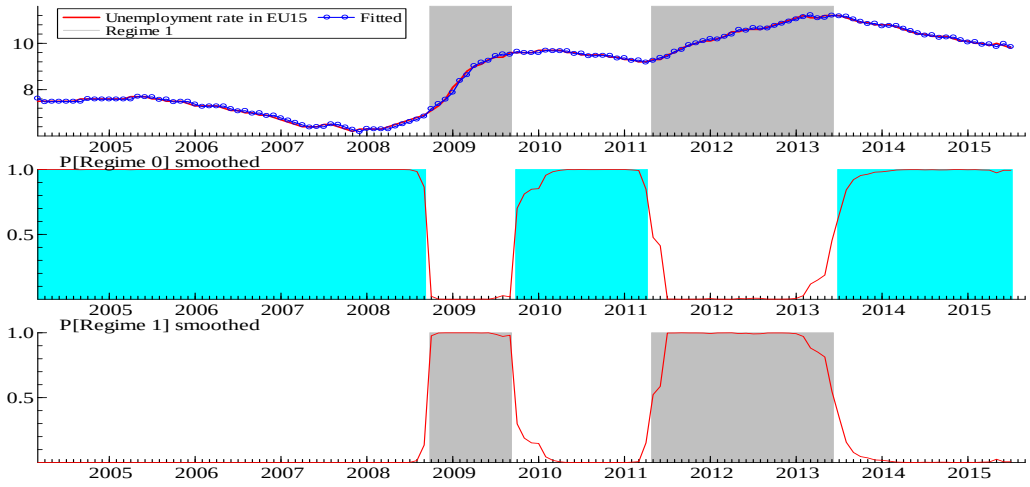

Figure 7. Two regimes of persistence in the EU15.

Table 10. Summary of estimated two-state MS models

Country/Region	Lower persistence estimate	Higher persistence estimate	Time spent in the unit-root/ mild explosive regime
EU15	<1	<1	-
The Czech Republic	<1	=1	57%
Estonia	<1	<1	-
Latvia	<1	=1	32%
Lithuania	<1	<1	-
Malta	<1	=1	13%
Poland	<1	<1	-
Slovakia	<1	>1	16%
Slovenia	=1	>1	85%/15%

CONCLUSION

The persistence of the monthly unemployment rate was estimated for ten emerging European economics and for the EU15 from the beginning of 2004 until mid-2015. Several conclusions can be derived.

An extremely high level of persistence described by unit-root presence, even when the modelling accounts for structural breaks, is detected for Hungary and Cyprus. For other countries in the sample the hysteresis hypothesis has been strongly rejected.

However, to allow for a more sophisticated approach that provides the possibility of splitting unemployment rate dynamics into the hysteresis and the natural rate theory hypothesis, the Markov-switching autoregressive model is implemented. This estimation has enabled further insight into the unemployment rate persistence.

Two regimes of high unemployment persistence without unit-roots have been found for the EU15. Similar behaviour was observed for the unemployment rates in Poland, Estonia and Lithuania.

Unit-root presence was detected within one regime, and stationarity within the other regime in the Czech Republic, Latvia and Malta. In Slovakia, stationarity was also found in one regime, while mild explosive behaviour was estimated in another regime. Given the duration and prevailing trend behaviour of the unemployment rate over the unit-root (or explosive) regime, we may argue that the degree of the unemployment persistence in these countries is of a similar magnitude as in the EU15.

A combination of unit and mild explosive root was determined for the Slovenian unemployment rate. Since Slovenian data were mostly covered by the unit-root regime, while explosive behaviour was connected with a strong upward trend, our final conclusion points to the extremely high level of persistence in Slovenia. Overall, our quantifications show that the estimated unemployment persistence in Hungary, Slovenia and Cyprus is of greater magnitude than in the EU15. The level of persistence can be taken to be of similar magnitude in the other economies considered.

Our empirical results are not in line with findings previously reported in Cuestas, Gil-Alana and Staehr (2011) that considered data for sample that ends in 2007. Since our sample captures dynamics during and after the Great Recession, we may argue that unemployment rate persistence has changed dramatically as a consequence of the 2008-2009 crisis. In fact, the LS unit-root test identifies the second half of 2008 as a break date for most time-series.

Returning to the behaviour of the unemployment rate dynamics explained by the Markov-switching autoregressive model, some additional points can be made. First, the frequency of regime switching differs substantially across countries. For example, the unemployment rate in the EU15 went through one regime twice and through the other regime once. The same holds for the Czech Republic. A shorter duration of regimes (more frequent regime switching) is estimated in other countries. This finding suggests that unemployment rates do not adjust with a similar speed to new equilibrium levels across different economies. Second, short-run dynamics vary significantly across estimated models because they are represented by different numbers of lagged changes in the unemployment rate that range from one to five. Such a result emphasizes a different degree of inertia in the unemployment rates. Third, no unique conclusion can be drawn concerning the correlation between level of unemployment persistence and its mean level or variability. It is evident that the dynamics of unemployment rates are characterized by different patterns indicating that country-specific measures of economic and employment policy should be implemented.

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