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Article

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Regime Switching Modeling of Unemployment Rate in Eastern Europe

Iryna LUKIANENKO – Marianna OLISKEVYCH** – Olena BAZHENOVA****

Abstract

This paper investigates the unemployment rate dynamics in Poland, Hungary, Slovakia, Latvia, Lithuania, Estonia, Bulgaria, Romania and Ukraine during 2000 – 2017. To analyze the dynamics of unemployment rate we constructed econometric regression models with nonlinearities that arose due to discrete changes in modes. We developed Markov switching model that allowed capturing the regularities by modeling the asymmetry in the unemployment rate during contractionary and expansionary states of the labor market. We evaluated two regimes of unemployment behavior that were associated with high and low unemployment levels and estimated the transition probabilities of regime change and average expected durations in each regime. The comparison of mean and volatility of different regimes and the one-step ahead predictions of the regime probabilities for different countries revealed the labor market specifics for each country and showed differences in the flexibility of their reactions to changing economic environment.

Keywords: *labor market, unemployment, switching model, Markov chain, Eastern Europe*

JEL Classification: C24, E24

Introduction

Harmonization of the economic processes and convergence within the European Union are importantly associated with real convergence measured by the real income per capita, gross capital formation, domestic investment as well as

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unemployment rate and labor productivity (Durkalic et al., 2019) that during recent decades exhibit different patterns of behavior for different Eastern European countries. High unemployment and its instability have a considerable impact on social instability, especially in recession periods, and are the reasons of growing of inequalities and sharpening wealth polarization among the population. Even for countries where unemployment is below the EU average, the assumption that unemployment benefits and other direct costs connected with unemployment create small expenditure is dubious. In this regard, Jahoda and Godarova (2016) showed that the negative impact of unemployment on public wealth was considerable in the Czech Republic and was even a little higher than in a similar economy. Despite the fact that in the short run unemployment can stimulate saving rate, the adjustment is fast and most of the disequilibrium that occurred is eliminated in the next quarter (Pitonakova, 2015). Development of unemployment has an influence on the development of wage. In the long run, higher unemployment has a negative effect on household saving that deepens the inequality in further periods.

Pauhofova and Stehlikova (2018) analyzed the behavior of unemployment in Slovakia, Czech Republic and Hungary and found out that in regions with higher unemployment the increase in wages was lower.

In most European countries, unemployment rate showed stable or decreasing dynamics for the duration of Great Moderation period and then rapidly increased after 2008 crisis. Despite of the fact that unemployment jumped sharply due to the crisis its dynamics appeared the fluctuations caused by business cycles. The investigation of cycle's duration and mean reversion of unemployment in some papers was performed by means of non-accelerating inflation rate of unemployment approach (Šarmír, 2006; Čížek, 2015) and examining of structural break. Nevertheless, other investigations revealed that unemployment rate in Europe showed persistence and argued with NAIRU hypothesis (Cuestas and Gil-Alana, 2017; Srinivasan and Mitra, 2012).

Persistence of employment is often discussed with hysteresis properties that suppose that all shocks can have a permanent impact on the level of unemployment. However, this issue has contradictory support in empirical literature. The investigation of hysteresis in unemployment for Visegrad Group countries by means of common unit root test, seemingly unrelated regressions augmented Dickey-Fuller test as well as by Fourier Dickey-Fuller test revealed that the hysteresis has effect on unemployment rate only for Hungary and Poland and does not have significant impact for Czech Republic and Slovakia (Furuoka, 2014). In some countries, unemployment rate exhibited multiple equilibrium properties and fluctuated around ineffective equilibrium for a long time (Čížek, 2017).

To overcome challenges that create unemployment it is important to understand its different and nonlinear dynamic pattern related to different phases of economic cycle that revealed to have a different durations as well as different magnitudes of fluctuations for Eastern European countries. Therefore, in the modeling of processes which behavior is described by different regimes that change each other, it is necessary to use flexible econometric tools that allow different types of behavior over time.

In our paper, we examine the unemployment rate of Eastern European countries during 2000 – 2017 by the Markov switching autoregressive model in order to describe different behavior in the contractionary and expansionary regimes and to explain the asymmetry in its movements. For this purpose, we need to use switching autoregressive models that are non-linear models arising from discrete changes in regime. These models can allow also a change of the model specification depending on the values of some variables that can be among the explanatory variables as well as due to the presence of autocorrelated errors. We have considered Markov switching models that allow taking into account various time-depended regimes of movement and explain the series behavior in different modes by estimating one model and transition matrix probability for these modes.

Literature Review

Dramatic changes in behavior related to different factors have been found in many economic time series (Jeanne and Masson, 2000; Cerra and Saxena, 2005) as well as in government policy (Davig, 2004; Lukianenko and Dadashova, 2016). Economists have a particular interest in investigation of many economic variables that behave quite differently during downturns and declines of economic activity, when the insufficient usage of production factors rather than their long-term growth tendency governs economic dynamics (Hamilton, 1989; Chauvet and Hamilton, 2006). Sharp changes are a common feature of financial data. In particular, it has been shown that changes in fundamental assets are reflected in asset prices (Garcia, Luger and Renault, 2003). Dynamic structural model that took into account price factor and regime-shift risks in changes of the regime was developed by Dai, Singleton and Wei (2007), while the risk factors were described by the discrete-time Gaussian process and regime shifts were described by the discrete-time Markov process with state-dependent transition probabilities. Cai (1994) combined Hamilton's switching regime model and Engle's autoregressive conditional heteroskedasticity (ARCH). He developed a Markov-ARCH model for the monthly excess return of the Treasury bill. Ghiani, Gillman and Kejak (2014) developed a Markov switching model with three regimes to investigate the behavior of M2 and M1 monetary aggregates and the Federal Funds rate in the United States and found a cointegration of interest rate, inflation, unemployment and the money supply.

Switching models are also widely used to model the processes in the real sector of economy as well as socio-economic processes. Camacho (2011) investigated the persistence of the dynamic output response to the random disturbances and showed that US GDP was described by the trend -stationary Markov switching process better than by having a regime-dependent unit root. Alizadeh, Huang and Dellen (2015) investigated the input of petroleum transportation and production in the energy supply chain during 2005 – 2013 and developed the regime switching GARCH specification and the bivariate Markov Regime Switching GARCH model. The research revealed different behaviors for different market conditions and showed that the tanker freight market was characterized by different regimes from high to low volatility. Pelletier (2006) used a system of switching models with Markov chain to decompose a covariance matrix on correlations and standard deviations and constructed multi-step ahead conditional expectations to improve the dynamic Conditional Correlation model. Billio and Sanzo (2015) proposed a new approach to causality testing using models that take into account changes in regimes according to multi-dimensional Markov chains. They investigated the relationship between financial and economic cycles in the US using the bivariate Markov switching model and predicted aggregate economic activity. Herwartz and Lutkepohl (2014) used a structural vector autoregressive (SVAR) analysis and Markov regime switching (MS) to investigate the impact of structural shocks if the reduced form error of the covariance matrix varies across regimes. Bergman and Hansson (2005) estimated a Markov switching model with AR (1) structure for the real exchange rate that allowed multiple switches between two regimes in order to distinguish between a stationary process subject to structural breaks and a unit root process (Brooks, 2008).

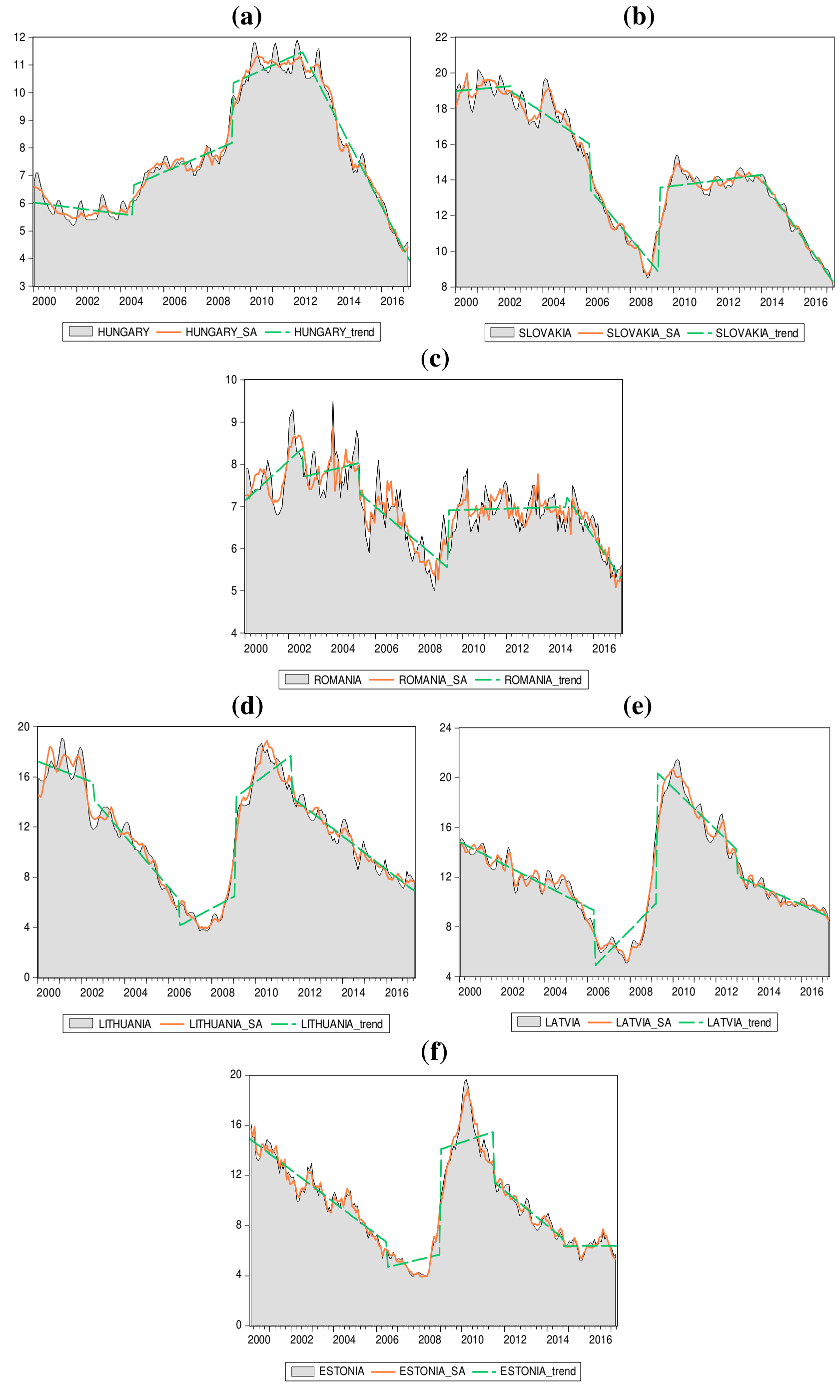
Different regimes in behavior are also naturally distinguished for processes in the labor market (Oliskevych, 2015). In particular, a number of researchers used nonlinear models to model the unemployment behavior. Cevik and Dibooglu (2013) investigated non-linearity of the US unemployment rate using a regime-switching unit root test and showed that the impact of shocks on unemployment was persistent during recession periods. They supported the hypothesis of hysteresis indicating a loss of valuable job skills in protracted recessions. Nethunayev and Glass (2017) studied the transmission mechanism and spillover effects of local and foreign economic policy uncertainty shocks on employment in the two largest economic regions, the United States and Europe. They developed the Bayesian Markov-Switching Structural Vector Autoregressive (MS-SVAR) and showed the effect of foreign uncertainty shocks on the Eurozone and the lack of such influence in the United States emphasizing the surplus of both local and foreign uncertainty shocks in fluctuation periods with greater volatility. Juhn, Potter and Chauvet (2002) developed a dynamic factor model with Markov switching to investigation the secular and business cycle fluctuations in the US unemployment rates over the business cycles and found strong evidence of the existence of a common factor and switching between high and low unemployment regimes. Lee and Chang (2008), Franchi and Ordonez (2008) found the hysteresis and common force that led to nonlinear behavior and smoothed trend-stationary transition in the European unemployment rate around highly persistent structural changes. Schwartz (2012) estimated the Markov Switching Models (MS) for unemployment rate, average duration of unemployment, jobless claims and the exhaustion rate of regular unemployment insurance during 1972 – 2008. Papageorgiou (2014) investigated the processes of occupation switching. He determined the key facts of professional mobility, ++ studied the comparative advantages and revealed the effect of the unemployment duration on labor productivity.

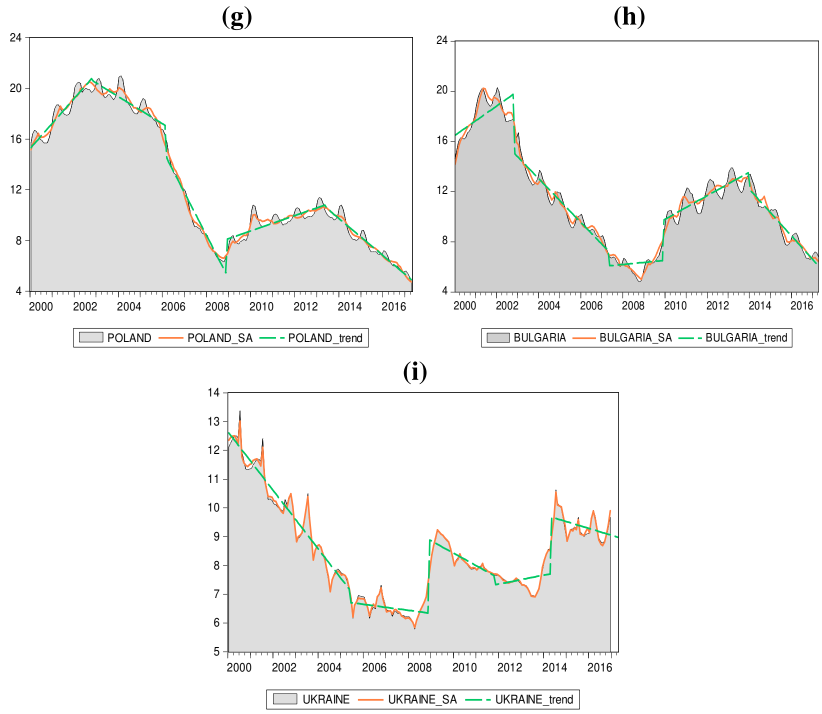
In recent decades, EU members demonstrated high levels of unemployment rate with increased long-term unemployment level. The unemployment rate depends on many factors that have different degrees of significance in different countries (see Figure 1). In the long run, the demographic trends in the country and the level of education, the population age structure (Biagi and Lucifora, 2008), age and cohort effects (Balleer, Gomez-Salvador and Turunen, 2014), long-term relationship between unemployment rate and other macroeconomic variables, especially GDP and inflation, youth economic activity (Caporale and Gil-alana, 2014) are of importance. Differences in the level of unemployment in different countries are also due to significant differences in the labor force participation of women (Abdulloev , Gang and Yun, 2014; Naidu, 2016). The important determinants are international competitiveness of countries (Kharlamova and Vertelieva, 2013), balanced regional development (Klebanova et al., 2009) and international migration (Christofides et al., 2007).

Demographic trends explain only the part of the changes in the labor market, the rest are due to cyclical factors. In particular, significant increase in unemployment has been observed during recessions. The unemployment rate was related to economic activity of the working-age population during the business cycles (Blanchard and Gali, 2007; Papapetrou and Bakas, 2013). The scientists also revealed the importance of the sensitivity of economic activity and unemployment to changes in wages, taxes, transfers (Yuldashev and Khakimov, 2011; Senaj et al., 2016), structural technological shocks, labor demand shocks, labor supply shocks and wage-setting shocks (Lukianenko and Oliskevych, 2015).

F i g u r e 1

The Dynamics of Unemployment Rate of (a) Hungary; (b) Slovakia; (c) Romania; (d) Lithuania; (e) Latvia; (f) Estonia; (g) Poland; (h) Bulgaria; (i) Ukraine during 2000 – 2017





Source: Data from Eurostat Database and State Statistics Service of Ukraine, elaborations of the authors.

The research of 40 OECD countries showed that the gross worker flow into the unemployment pool had been accompanied by an increase in unemployment, while the outflow of potential employees from the labor force and their transition to inactive state with a certain lag caused a negative shift in unemployment (Elsby, Hobijn and Sahin, 2013). Among the significant factors of unemployment, scientists also emphasized the level of education, the development of social security programs (Katay and Nobilis, 2009), pay inequality, cohesion and competitiveness (Galbraith and Garcilazo, 2010), labor force health (Kalwij and Vermeulen, 2008) that were different for different European countries.

The different patterns of unemployment behavior over different phases of business cycle scientists explain by a wide range of approaches. Kaplan and Menzio (2016) introduced the theory of self-fulfilling unemployment fluctuations that implied that during the expansion period, when firms increase the workforce, the employed workers have less time to look for the low prices in comparison to unemployed workers so they spend more increasing demand and weakening competition among the firms. Recent study showed that considerable fraction of employed labor force was underemployed due to the fact that substantial pool of workers took the job positions for which they were overqualified. By building a search model with endogenous ranking methodology, Barnichon and

Zylberberg (2019) showed that high skilled workers agreed to be underemployed to avoid the challenges associated with competition for more profitable job and to find job more quickly that caused the obstacles to find a relevant job for less skilled workers. The scientists emphasized that the fraction of underemployment rate is higher during the recessions where both the underemployment rate and the wage loss connected with becoming underemployed go up which leads to an increase in total unemployment rate.

After 2008 financial crisis, most European countries experienced severe economic recession accompanied with sharp sizable unemployment rise and output drop. Bertola (2017) suggested that capital flow and reforms implications of international economic integration are crucial for interpreting twists and turns of unemployment rates in Europe. Brecher and Gross (2019) received empirical evidence that a hike in the minimum wage despite the negative implication for lifetime utility and growth rate does not increase the total unemployment. The modern concepts of unemployment investigation represented by the self-perceived labor market status demonstrated that the changes in labor regulation rules help to lower the probability of high unemployment (Babos and Lubyova, 2016).

The scientists investigated whether unemployment is mostly structural or cyclical and evaluated natural and cyclical components of unemployment. Wisniewski and Maksim (2017) investigated the nature and structure of unemployment in the period 2005 – 2015 as well as the development of labor market policies in Poland. Krasnopjorovs (2015) examined unemployment in Latvia and showed that stimulating demand policies could not decline the unemployment without pressure on inflation and competitiveness whereas the improvement of efficiency in matching between unemployed workers and available vacancies could decrease the natural level of unemployment rate especially among managers and professional occupations. Examining the structural and cyclical components of unemployment by combining the decomposition and matching approaches, Cuestas and Gil-Alana (2017) measured the duration of cycles using quarterly unemployment rates for Austria, Belgium, Finland, France, Germany, Italy, Ireland, Netherlands, Portugal, Spain and the UK. They examined the order of integration taking into account possible fractionally cyclical integration of unemployment rate and evaluated non-integer integration orders that provided a more flexible approach. Arpaia, Kiss and Turrini (2014) tried to separate the temporary changes in the relationship between the unemployment and vacancies from the structural shifts that influenced the effectiveness of matching on the labor market and found that the efficiency of matching became progressively worse after 2008 crisis particularly because of increase in the duration of being unemployed and mismatching of skills. They also revealed some divergence processes and heterogeneity among European countries.

The employment tardiness in the last recoveries and hysteresis of unemployment are in focus of contemporary empirical literature. Shimer (2005) emphasized the impact of wage rigidities. Wiczer (2017) stressed on the importance of unemployment duration heterogeneity across different occupations and sectors. Based on panel data for 23 OECD that included a long period of time from 1963 to 2007, Kanalici Akay, Nargelecekenler and Yilmaz (2011) provided evidence that rejected the unemployment hysteresis hypothesis for the OECD and supported the structural view. Jiang et al. (2019) used quantile unit root test with both sharp shifts and smooth breaks to investigate hysteresis effect for G7 countries for period 1980 – 2017. The results based on conventional unit root tests indicated the hysteresis in unemployment for half of G7 countries. The results based on quantile Kolmogorov-Smirnov test as well as on quantile unit root test with both sharp shifts and smooth breaks reject this hypothesis. Akdoğan (2017) built an exponential smooth transition autoregressive and asymmetric exponential smooth transition autoregressive models in order to explain the nonlinear mean-reverting behavior in unemployment caused by heterogeneity in hiring and firing costs across firms and rejected the hysteresis hypothesis for more than half of the pool of countries that included 31 European countries, the USA and Japan. The research proved that nonlinear models can capture the asymmetries in unemployment dynamics over the business cycle for some countries and revealed multiple structural breaks that might indicate the shifts in mean level of unemployment. Xie and Chang (2018) studied the hypothesis of unemployment hysteresis for nine Eastern European countries, Bulgaria, Lithuania, Latvia, Poland, Slovakia, Czech Republic, Hungary, Romania and Russia, by applying unit root tests with smooth multiple breaks using Fourier function. They showed that the shocks influenced unemployment of these countries are asymmetric and showed the existence of unemployment hysteresis only for two countries, Hungary and Romania.

Čížek (2017) provided evidence that the baseline search-matching model that assumes the unique steady state was not able to capture highly persistent large swings in behavior of unemployment and proved that the model with multiple equilibria in comparison with basic model can improve matching of statistical moments and quality of forecast performance. He developed a novel approach of incorporating the weak demand principle into the basic search and matching model introduced by Hagedorn and Manovskii (2008) and created a multiple equilibria model that takes into account possible fluctuations of unemployment rate around ineffective equilibrium in the long run. Čížek (2017) found that weak demand principle and multiple equilibria can explain the observed persistence as well as huge fluctuations in unemployment on the Spanish labor market. The author also described a mechanism that causes unemployment rate to converge to the higher-level equilibrium. Plotnikov (2019) built the model to explain the persistence of unemployment development in USA after the 2008 crisis together with other recessions. He focused on the changes in wealth that affected the speed of the employment recovery, evaluated a general equilibrium rational expectation model with multiple steady state equilibria and revealed the hysteresis and path-dependence of unemployment rate. According to multiplicity of equilibria, if wealth did not recover because of fundamental or non-fundamental reasons, unemployment could stay in high-level equilibrium for a long time.

Recent studies found the way of improvement in unemployment forecast accuracy using novel measures of consensus among agents' expectations that are proved to take an advantage over alternative aggregation procedures of qualitative survey expectations. Consumers' expectation that are different for different phases of business cycle are important for the unemployment forecasts. Claveria (2019) built the selected optimal autoregressive integrated moving average models based on step-wise algorithm and used them to generate out-of-sample recursive forecasts of the unemployment rates for eight European countries. It was revealed that the indicator of unemployment, which is based on the degree of agreement in consumer unemployment expectations, and the measure of disagreement, which is based on the dispersion of expectations, had an influence on the prediction of the turning point of unemployment development. However, each country represented the variation of improvements because of differences in the explanatory power of the agreement indicators and the country-specific factors that reflected the labor market and consumers predictive capacity heterogeneities.

Data Analysis

We performed an empirical statistical analysis and econometric modeling of unemployment rate movement in seven different recent European Union member states and Ukraine that in recent years experienced significant structural shifts and military actions. The statistical investigation was conducted for a monthly data from January 2000 until April 2017. We used data from Eurostat database and from statistical reports of State Statistics Service of Ukraine. Figure 1 depicts the behavior of unemployment rate in Poland, Slovakia, Hungary, Latvia, Lithuania, Estonia, Romania, Bulgaria and Ukraine. The smooth curves in Figure 1 define the dynamic paths of seasonally adjusted data that were obtained by using CensusX12 method. The straight lines were calculated by using the estimated linear trend models that contained dummy variables and allowed us to evaluate the different intersections and different slope coefficients for different periods.

Table 1 and 2 represents the mean, maximum and minimum values of the adjusted unemployment rate series, their standard deviations, as well as Jarque-Bera statistics along with corresponding p-values for testing the normal distribution of unemployment in new EU members, Ukraine and Norway (for comparison).

T a b l e 1

The Statistical Characteristics of Unemployment Rate in Slovakia, Hungary, Poland, Bulgaria and Romania during 2000 – 2017

	SLOVAKIA	HUNGARY	POLAND	BULGARIA	ROMANIA
2000 – 2003					
Mean	18.638	5.838	18.667	15.993	7.811
Maximum	19.975	6.592	20.522	20.263	8.848
Minimum	17.317	5.453	15.162	11.343	7.073
Std. Dev.	0.715	0.339	1.484	2.881	0.455
Jarque-Bera	3.198	10.257	7.520	5.394	2.432
Probability	0.202	0.006	0.023	0.067	0.296
2004 – 2008m6					
Mean	13.182	7.384	12.898	8.298	6.698
Maximum	17.329	8.027	18.468	11.057	7.957
Minimum	9.868	6.595	6.965	5.700	5.572
Std. Dev.	2.400	0.280	4.017	1.634	0.657
Jarque-Bera	3.798	3.705	3.706	3.229	1.250
Probability	0.150	0.157	0.157	0.199	0.535
2008m7 – 2010m6					
Mean	11.981	9.827	8.194	7.195	6.394
Median	12.065	10.091	8.111	6.691	6.471
Maximum	14.916	11.321	10.035	10.074	7.426
Minimum	8.683	7.538	6.596	5.005	5.263
Std. Dev.	2.362	1.281	1.137	1.757	0.653
Jarque-Bera	2.531	2.312	1.406	2.313	1.748
Probability	0.282	0.315	0.495	0.315	0.417
2010m7 – 2013m11					
Mean	13.989	10.829	9.971	11.962	7.001
Maximum	14.511	11.291	10.654	13.124	7.767
Minimum	13.437	9.360	9.340	9.992	6.517
Std. Dev.	0.314	0.472	0.392	0.839	0.268
Jarque-Bera	2.394	27.668	2.614	1.844	2.011
Probability	0.302	0.000	0.271	0.398	0.366
2013m12 – 2016m3					
Mean	12.168	7.167	8.124	10.143	6.767
Maximum	13.986	8.718	9.935	13.043	7.183
Minimum	10.072	5.585	6.428	7.954	6.201
Std. Dev.	1.219	0.799	1.069	1.553	0.239
Jarque-Bera	1.584	0.839	1.390	1.546	3.378
Probability	0.453	0.657	0.499	0.462	0.185
2016m4 – 2017m4					
Mean	9.184	4.737	5.716	7.145	5.606
Maximum	10.008	5.436	6.376	8.026	6.086
Minimum	8.277	4.281	4.729	6.413	5.085
Std. Dev.	0.592	0.394	0.619	0.543	0.345
Jarque-Bera	1.031	0.863	1.417	1.184	1.190
Probability	0.597	0.649	0.492	0.553	0.551

Source: Data from Eurostat Database and State Statistics Service of Ukraine, authors' evaluation.

T a b l e 2

The Statistical Characteristics of Unemployment Rate in Latvia, Lithuania, Estonia, Ukraine and Norway during 2000 – 2017

	LATVIA	LITHUANIA	ESTONIA	UKRAINE	NORWAY
2000 – 2003					
Mean	12.749	14.193	11.825	10.093	3.762
Maximum	14.859	18.384	15.912	13.014	4.507
Minimum	10.748	9.926	9.063	7.087	3.077
Std. Dev.	1.166	2.648	1.830	1.567	0.441
Jarque-Bera	4.685	5.648	4.105	2.763	4.956
Probability	0.096	0.059	0.128	0.251	0.084
2004 – 2008m6					
Mean	7.518	5.909	5.869	6.617	3.342
Maximum	11.285	9.409	9.344	7.686	4.672
Minimum	5.271	3.914	3.930	5.847	2.329
Std. Dev.	1.774	1.754	1.601	0.460	0.886
Jarque-Bera	5.533	4.756	3.219	4.833	5.136
Probability	0.063	0.093	0.200	0.089	0.077
2008m7–2010m6					
Mean	16.142	13.112	13.134	8.214	3.139
Median	18.766	14.234	13.997	9.237	3.151
Maximum	20.667	18.642	18.929	6.461	3.677
Minimum	7.134	5.573	5.389	0.839	2.482
Std. Dev.	4.784	4.158	4.344	2.946	0.349
Jarque-Bera	3.035	2.125	1.950	0.229	0.695
Probability	0.219	0.346	0.377		0.706
2010m7 – 2013m11					
Mean	15.061	14.227	11.078	7.571	3.353
Maximum	19.608	18.881	16.603	8.101	3.707
Minimum	11.234	11.283	8.037	6.908	3.006
Std. Dev.	2.399	2.182	2.431	0.330	0.181
Jarque-Bera	1.449	2.921	3.586	1.771	1.178
Probability	0.485	0.232	0.166	0.412	0.555
2013m12 – 2016m3					
Mean	10.344	9.752	6.793	9.251	4.028
Maximum	11.498	11.915	8.468	10.548	4.707
Minimum	9.658	7.859	5.363	7.935	3.216
Std. Dev.	0.602	1.191	0.831	0.601	0.500
Jarque-Bera	3.299	1.517	1.394	0.063	2.657
Probability	0.192	0.468	0.498	0.969	0.265
2016m4 – 2017m4					
Mean	9.352	7.814	6.568	9.154	4.634
Maximum	9.745	8.274	7.718	9.905	4.960
Minimum	8.508	7.409	5.312	8.688	4.204
Std. Dev.	0.390	0.253	0.762	0.424	0.220
Jarque-Bera	2.037	0.595	0.749	0.793	0.742
Probability	0.361	0.743	0.688	0.673	0.690

Source: Data from Eurostat Database and State Statistics Service of Ukraine, authors' evaluation.

We calculated the statistical characteristics of the series for different sub-samples by breaking the general sample for several periods that characterized different trends in the dynamics of unemployment. It should be noted that the countries that joined the European Union in 2004 after their accession and until the end of 2008 showed similar tendencies in reducing unemployment, despite the fact that before the accession to the EU the dynamics of unemployment in these countries significantly differed. In the period from 2008 to 2010, the unemployment rate increased for all countries but dynamics and absolute value of growth were different. The unemployment rate behavior over the past seven years demonstrated large differences in various countries that reveals the specifics of the labor markets in various East European countries and their different properties in terms of overcoming the downturn and the possibility of employment renewal. The visual analysis and statistical characteristics of the series show that in Slovakia, the Czech Republic, Hungary, Romania, the unemployment rate has started to decrease since the end of 2013, remaining relatively unchanged at a high level in 2010 – 2013. In the Baltic countries, the unemployment rate has sharply increased from 2008 to 2010, but after these two adverse years in the next 3 years (2010 – 2013) it has rapidly fallen and now continues to decrease. In Poland, Bulgaria, Slovenia, Croatia the increase in unemployment did not stop in 2010 and continued to increase gradually until the end of 2013. In Ukraine, the unemployment rate went up abruptly again in 2014. Now it remains high due to military actions of Russia in the east of the country that causes destabilization in the labor market in all regions of Ukraine.

Modeling Methodology

The linear regression model is one of the main tools for statistical and econometric analysis of the economic variables behavior. However, there is evidence that nonlinear modeling is more appropriate in conditions of unstable internal and external environment (Hamilton, 2008; Schwartz, 2012). Nonlinear methods are particularly relevant for analysis of macroeconomic processes that are characterized by structural changes in behavior and changes in dynamic relationships.

The investigation of many economic time series dynamics, in particular the indicators of the social sphere, shows the existence of regimes in which the movement of the series changes quite sharply. If the behavior of the series changes once and for good, this change is reflected in the model as a structural break. The behavior may also change over time and then the series return to its original behavior. In this situation, one can try to build separate linear models for different sub-samples but this approach leads to inefficiency and waste of statistical information and in addition in case of short-term regimes the estimation of model parameters are not available. At the same time, from an empirical point of view it is very restrictive to suppose that there is only one break in intercept. There are the episodes when the intercept changes over time and different intercepts are associated with different regimes of behavior and economic conditions. In addition, the behavior of the series may change over time not only in terms of its mean. Other model parameters may also change over time. In particular, the relation of current and lagged value as well as volatility of time series can change over time. The regime changes can occur deterministically at defined time or the modes can change each other randomly with some probabilities.

We conducted an econometric analysis of different regimes of the unemployment behavior by using dynamic switching models. The basis for the dynamic switching model is the first-order auto-regression model. Suppose that for $t = 1, 2, ..., t_0$ the behavior of the variable is adequately describe by the first-order autoregressive process (Hamilton, 2008)

$$y_t = \alpha_1 + \varphi\, y_{t-1} + \varepsilon_t \tag{1}$$

with $\varepsilon_t \sim N(0, \sigma^2)$ and significant changes occur in the average level of the variable at date t_0. Accordingly, for the next periods $t = t_0+1, t_0+2, ...$ the behavior of the variable is subject to the first order autoregressive process with another value of the intercept

$$y_t = \alpha_2 + \varphi\, y_{t-1} + \varepsilon_t \tag{2}$$

The modeling (1) – (2) takes into account deterministic shifts in the dynamics of the variable by estimating the fixed changes in the values of the intercept from α_1 to α_2 and, accordingly, improving the forecasts quality. However, this approach does not allow us to describe a probability distribution that adequately characterizes the data.

For economic indicators in general and labor market indicators, in particular, changes from α_1 to α_2 and at date t_0 may not be the deterministic event, in addition, it is usually not possible to predict them precisely ahead from date $t = 1$. But we can assume the presence of imperfectly predictable forces that with some probability cause these changes. Instead of asserting that the model (1) describes the behavior of the series up to date t_0 and the model (2) describe its dynamics after that date we consider some wider model specification encompassing both previous models

$$y_t = \alpha_{r(t)} + \varphi\, y_{t-1} + \varepsilon_t \tag{3}$$

where r_t is a random variable which as a result of economic disturbances, structural and institutional changes, can take values $r_t = 1$ and $r_t = 2$. In order to describe the probability distribution that adequately characterizes the observed data it is necessary to determine a probabilistic model that cause the changes from $r_t = 1$ to $r_t = 2$. Therefore, suppose that r_t is the realization of a two-state Markov chain with

$$\text{Prob}\ [\ r_t = j \mid r_{t-1} = i,\ r_{t-2} = s,\ ...,\ y_{t-1},\ y_{t-2},\ ...\ ] = \text{Prob}\ [\ r_t = j \mid r_{t-1} = i\ ] = p_{ij} \quad (4)$$

We cannot observe r_t directly but we infer its value from the observed behavior of y_t.

We can represent Markov chain as a vector autoregressive process by letting 2×1 random vector η_t as follows (Bergman and Hansson, 2005)

$$\eta_t = \{\ (1\ \ 0)'\ \text{ if }\ r_t = 1; \quad (0\ \ 1)'\ \text{ if }\ r_t = 2\ \} \quad (5)$$

If r_t = 1 the first element in η_{t+1} is the random variable that takes the value 1 with the probability $p_{11} = 1 - p_{12}$ and zero otherwise. The conditional expectation of η_{t+1} given r_t=1 is represented in the first column of the transition matrix P, that is

$$\text{E}\ [\ \eta_{t+1} \mid r_t = 1\ ]\ =\ (\ p_{11},\ 1 - p_{11}\ )' \quad (6)$$

From (5), (6) and Markov properties (4) it follows that

$$\text{E}\ [\ \eta_{t+1} \mid \eta_t,\ \eta_{t-1},\ \eta_{t-2},\ \dots\ ]\ =\ P\ \eta_t \quad (7)$$

where

$$P = \begin{pmatrix} p_{11} & p_{21} \\ p_{12} & p_{22} \end{pmatrix} = \begin{pmatrix} p_{11} & 1 - p_{22} \\ 1 - p_{11} & p_{22} \end{pmatrix}$$

which further implies that it is possible to rewrite Markov chain as the first order vector autoregression

$$\eta_{t+1} = P\ \eta_t + v_{t+1}$$

where $v_{t+1} = \eta_{t+1} - \text{E}\ [\ \eta_{t+1} \mid \eta_t,\ \eta_{t-1},\ \eta_{t-2},\ \dots\ ]$ is martingale difference sequence.

Therefore, unobserved second component of vector η_t , $\eta_{2,t}$, evolves as an AR(1) process

$$\eta_{2,t} = (1 - p_{11}) + \rho\ \eta_{2,t-1} + \xi_t \quad (8)$$

where $\rho = p_{11} + p_{22} - 1$. As results, the state variable r_t is given as a generalization of the dummy variables with one shift in a series. Under the Markov switching approach, there can be multiple shifts from one set of behavior to another.

Next, the observed unemployment series evolves as

$$y_t = \mu_1 + \mu_2\ r_t\ + (\sigma_1^{\ 2} + \varphi\ r_t\ )^{1/2}\ u_t \quad (9)$$

where y_t – unemployment rate and $u_t \sim$ N(0, 1). The expectation and volatility of the series are μ_1 and $\sigma_1^{\ 2}$ in state 1, and $(\mu_1 + \mu_2)$ and $\sigma_2^{\ 2} = \sigma_1^{\ 2} + \varphi$ in state 2 respectively. Therefore, the model has six unknown parameters (μ_1, μ_2, $\sigma_1^{\ 2}$, $\sigma_2^{\ 2}$, p_{11}, p_{22}) that need to be estimated using maximum likelihood.

Markov switching regimes can also be used in modeling by higher-order autoregressive models (Bergman and Hansson, 2005; Schwartz, 2012)

$$y_t = \alpha_{r(t)} + (\varphi_1)_{r(t)}\, y_{t\text{-}1} + (\varphi_2)_{r(t)}\, y_{t\text{-}2} + \ldots + (\varphi_p)_{r(t)}\, y_{t\text{-p}} + (\sigma)_{r(t)}\, \varepsilon_t \qquad (10)$$

where ε_t has normal distribution N(0, 1). In the case of two regimes, there are 2 (p + 3) unknown parameters that we can collect in vector

$$\psi = (\alpha_1, \alpha_2, (\varphi_1)_1, (\varphi_1)_2, (\varphi_2)_1, (\varphi_2)_2, \ldots, (\varphi_p)_1, (\varphi_p)_2, (\sigma_1)^2, (\sigma_2)^2, p_{11}, p_{22})'$$

The information set in period t is based on all observations y_t known until this date, i.e. the information set is given by the vector $Y_t = (y_0, ..., y_t)$ ‘. Then the conditional density of y_t given the process was in regime j at date t is

$$f(y_t \mid r_t = j, Y_{t\text{-}1}; \psi) = 1/\left((2\pi)^{1/2}\, \sigma_j\right) \exp\left(-(y_t - \alpha_j - (\varphi_1)_j\, y_{t\text{-}1} - (\varphi_2)_j\, y_{t\text{-}2} - \ldots - \right.$$
$$\left. - (\varphi_p)_j\, y_{t\text{-}p})^2 / (2\sigma_j^2)\right)$$

We collect both these density in vector f_t.

We cannot observe the values of the state variable r_t and, therefore, we determine the probability Prob [$r_t = j \mid Y_t;\ \psi$] by the econometric conclusions about the value of r_t using the available observed data known at time t and estimates of the parameters ψ. We combine these conditional probabilities in the vector $\hat{\eta}_{t|t}$. Likewise, we can also construct one-step ahead predictions of the regime probabilities Prob [$r_t = j \mid Y_{t\text{-}1};\ \psi$] and combine them in the vector $\hat{\eta}_{t|t\text{-}1}$. Choosing some initial value $\hat{\eta}_{1|0}$, the optimal conclusions about regime probabilities can be found from the following equation

$$\hat{\eta}_{t|t\text{-}1} = (\hat{\eta}_{t|t\text{-}1} \bullet f_t) \,/\, O' (\hat{\eta}_{t|t\text{-}1} \bullet f_t) \qquad (11)$$

$$\hat{\eta}_{t+1|t} = P\ \hat{\eta}_{t|t}$$

where O is a column vector of ones and • denote element by element multiplication. The full log-likelihood function is

$$l(\psi) = \textstyle\sum^{T}_{t=1} \ \log f\,(y_t \mid Y_{t\text{-}1};\ \psi) \qquad (12)$$

where

$$f\,(y_t \mid Y_{t\text{-}1};\ \psi) = O\,(\hat{\eta}_{t|t\text{-}1} \bullet f_t) = \textstyle\sum^{2}_{j=1} \text{Prob}\ [\ r_t = j \mid Y_{t\text{-}1};\ \psi] \cdot f\,(y_t \mid r_t = j, Y_{t\text{-}1};\ \psi) =$$
$$= 1/((2\pi)^{1/2}\sigma_1)\ \text{Prob}\ [r_t{=}1|Y_{t\text{-}1};\ \psi]\ \ \exp\left(-(y_t - \alpha_1 - (\varphi_1)_1\, y_{t\text{-}1} - (\varphi_2)_1\, y_{t\text{-}2} - \ldots - \right.$$
$$- (\varphi_p)_1\, y_{t\text{-}p})^2 / (2\sigma_1^2)\,) + 1/((2\pi)^{1/2}\sigma_2)\ \text{Prob}\ [r_t{=}2|Y_{t\text{-}1};\ \psi]\ \ \exp\left(-(y_t - \alpha_2 - (\varphi_1)_2\, y_{t\text{-}1} - \right.$$
$$\left. (\varphi_2)_2\, y_{t\text{-}2} - \ldots - (\varphi_p)_2\, y_{t\text{-}p})^2 / (2\sigma_2^2)\,\right)$$

In the case where probabilities are constants, they can be treated as additional parameters in likelihood function. To estimate the probabilities we use the polynomial logit specification

$$\text{Prob}[\, r_t = j \mid r_{t-1} = i, Y_{t-1}\,] = p_{ij}(\delta) = \exp(\delta_{ij}) \,/\, (\exp(\delta_{i1}) + \exp(\delta_{i2})),\ i=1,2;\ j=1,2 \quad (13)$$

where $\delta = (\delta_{11}, \delta_{12}, \delta_{21}, \delta_{22})$. We put $\delta_{i2}=0$ for the identifying normalization. Thus, the transition probabilities are estimated by formulas

$$p_{11}(\delta) = \exp(\delta_{11}) \,/\, (1 + \exp(\delta_{11})), \qquad p_{12}(\delta) = 1 \,/\, (1 + \exp(\delta_{11}))$$

$$p_{21}(\delta) = \exp(\delta_{21}) \,/\, (1 + \exp(\delta_{21})), \qquad p_{22}(\delta) = 1 \,/\, (1 + \exp(\delta_{21}))$$

The log-likelihood function (12) is maximized with respect to parameters (α; φ; σ; δ) using iterative methods.

Econometric Results

In order to identify different regimes of unemployment rate behavior we used MS-AR specification (10). The state variable r_t is assumed to follow a two-regime Markov process as described above. Our models includes different means and different variations for different regimes. To evaluate the transition probabilities we used the logit specification (13). For each country we estimated several models described by different orders, p, and next compared them based on a range of criteria. The estimation has been conducted by maximum likelihood method.

The results of Akaike and Schwartz information criteria, autocorrelation test based on Durbin-Watson statistics, logarithm of maximum likelihood as well as different measures of forecast evaluation such as root-mean-square error, mean absolute error, Theil's inequality coefficients (U) criteria with defined bias and variance proportions are given in Table 3. * indicate the best three models according to separate criteria. The results indicated different order of model for Eastern European countries.

Table 3

Diagnostic Results of High-order MS-AR Models for Unemployment Rate for East European Countries

Model Order	Information Criteria		Autocorrelation Test	ML	Forecast Evaluation				
	AIC	*SC*	*DW Statistics*	*log L*	*RMSE*	*MAE*	*Theil IC*	*Bias proportion*	*Variance proportion*
Poland									
$p = 1$	0.5660	0.6948	0.7594	–50.58	3.554	2.798	0.145	0.342	0.334
$p = 2$	–0.065*	0.0959*	1.7986*	16.76*	3.983	3.119	0.174	0.481	0.171*
$p = 3$	0.1517	0.3301	2.2453	–4.55	3.161*	2.472*	0.129*	0.192*	0.402
$p = 4$	**0.0370***	**0.2159***	**1.9883***	**7.22***	**3.352***	**2.741***	**0.139***	**0.324***	**0.258***
$p = 5$	0.1347	0.3143	1.8060*	–2.67	3.244*	2.703*	0.132*	0.242*	0.234*
$p = 6$	0.1724	0.3526	1.6675	–6.41	3.456	2.817	0.144	0.347	0.288

Bulgaria									
$p = 1$	0.6209	0.7497	1.0490	–56.26	3.237	2.65	0.144	0.077	0.689
$p = 2$	0.2875	0.4491	1.7022	–19.61	2.781*	2.32*	0.122*	0.038*	0.523
$p = 3$	0.0636*	0.2419*	1.6859	4.48*	3.935	3.24	0.153	0.27	0.624
$p = 4$	0.1090*	0.2879*	1.9626*	–0.12*	4.072	3.39	0.161	0.278	0.632
$p = 5$	**0.1369***	**0.3164***	**2.1157***	**–2.89***	**3.071***	**2.60***	**0.134***	**0.016***	**0.272***
$p = 6$	0.1541	0.3343	1.9443*	–4.569	4.313	3.67	0.168	0.351	0.571
Slovakia									
$p = 1$	0.5201	0.6489	1.2299	–45.84	2.169*	1.908*	0.075*	0.046*	0.466
$p = 2$	0.4481	0.6097	1.9425*	–36.16	3.573	2.962	0.128	0.357	0.109*
$p = 3$	0.3339*	0.5123*	2.1681*	–23.23*	2.156*	1.857*	0.074*	0.013*	0.486
$p = 4$	0.3622*	0.5411*	2.2535	–25.94*	4.232	3.469	0.131	0.542	0.421
$p = 5$	**0.4692**	**0.6487**	**1.9414***	**–36.62**	**2.682**	**2.314**	**0.094***	**0.165***	**0.019***
$p = 6$	0.5261	0.7063	1.8510	–42.14	2.168*	1.905*	0.076*	0.180	0.032
Latvia									
$p = 1$	1.1680	1.2968	1.1680	–112.8	3.764	2.664*	0.155*	0.014	0.503
$p = 2$	0.5501	0.7117	1.4241	–46.66	3.651*	2.743	0.147*	0.001*	0.719
$p = 3$	**0.5257^**	**0.7040^**	**2.0977***	**–42.89***	**3.829**	**2.684***	**0.160**	**0.026***	**0.494***
$p = 4$	0.5532	0.7322	1.7368	–45.43	3.926	2.733	0.165	0.043	0.442*
$p = 5$	0.6507	0.8302	1.5914	–55.04	3.813	2.693	0.159	0.026	0.570
$p = 6$	06936	0.8783	1.4603	–59.06	3.769	2.697	0.157	0.020	0.647
Lithuania									
$p = 1$	1.3906	1.5194	1.0587	–135.9	3.809	3.155	0.164	0.008*	0.681
$p = 2$	1.0314*	1.1930*	1.9435*	–96.24	3.885	3.193	0.172	0.072	0.569
$p = 3$	1.1010	1.2793	2.0903	–101.8	3.768*	3.081*	0.162*	0.010*	0.575
$p = 4$	1.0731	1.2520	2.1473	–98.45	3.827*	3.110*	0.165	0.013	0.477*
$p = 5$	1.0734	1.2529	2.0924*	–97.95	3.859	3.11*8	0.167	0.011*	0.402*
$p = 6$	**0.9749***	**1.1550***	**2.0435***	**–87.46***	**3.849***	**3.160**	**0.160***	**0.027**	**0.577**
Estonia									
$p = 1$	**1.6288***	**1.7585***	**1.9564***	**–158.9**	**3.309***	**2.330***	**0.171***	**0.045***	**0.284***
$p = 2$	1.6383*	1.8009*	2.0486	–157.1	3.481	2.433*	0.186	0.136	0.283*
$p = 3$	1.6447	1.8242	1.9819*	–155.9	3.445	2.459*	0.184	0.120	0.327*
$p = 4$	1.6096*	1.7898*	2.1171	–151.5*	3.423	2.583	0.183	0.102*	0.433
$p = 5$	1.6405	1.8213	2.0784	–153.8	3.307*	2.624	0.169*	0.001*	0.718
$p = 6$	1.6408	1.8222	2.0030*	–153.0	3.320*	2.483	0.174*	0.033	0.542
Ukraine									
$p = 1$	–0.1791	–0.0486	1.6431	26.187	1.222*	1.001*	0.069*	0.101*	0.307*
$p = 2$	0.0436	0.2073	2.3698	5.5962	1.700*	1.379	0.092	0.484	0.165*
$p = 3$	**–0.456***	**–0.276***	**2.1257***	**56.91***	**1.179**	**0.996***	**0.068***	**0.047***	**0.450**
$p = 4$	–0.4138	–0.2324	2.4117	52.38	1.167*	0.981*	0.067*	0.062*	0.424
$p = 5$	0.0677	0.2498	2.5783	4.2553	1.904	1.580	0.103	0.571	0.100*
$p = 6$	–0.3976	–0.2149	2.5326	50.36	1.199	1.002	0.069	0.123	0.426
Hungary									
$p = 1$	–0.3352	–0.2059	1.2372	42.52	2.766	2.122	0.195	0.324	0.417*
$p = 2$	–0.4632	–0.3011	1.7766	57.47	2.270*	1.799*	0.149*	0.069*	0.768
$p = 3$	–0.4602	–0.2813	2.1321	57.94	2.386*	1.860*	0.161*	0.169*	0.719
$p = 4$	–0.513*	–0.334*	2.0796*	63.14*	2.636	2.006	0.184	0.312	0.577*
$p = 5$	**–0.561***	**–0.380***	**1.9235***	**67.66***	**3.085**	**2.352**	**0.224**	**0.436**	**0.324***
$p = 6$	–0.4448	–0.2640	1.8857	55.70	2.257*	1.688*	0.153*	0.216*	0.663
Romania									
$p = 1$	0.7900*	0.9188*	2.0470	–73.77	0.826*	0.633*	0.058	0.005	0.764
$p = 2$	**0.8153**	**0.9768***	**1.9848***	**–73.97**	**0.827***	**0.637***	**0.058**	**0.006**	**0.758***
$p = 3$	0.8148	0.9931	2.0457	–71.52*	0.836	0.644*	0.059	0.002*	0.823
$p = 4$	0.8006*	0.9795*	1.9605*	–70.66*	0.844	0.653	0.060	0.004	0.929
$p = 5$	0.8382	1.0177	2.0741	–74.08	0.840	0.650	0.060	0.001	0.934
$p = 6$	0.8146*	0.9948	1.9641*	–71.28*	0.835*	0.645	0.059	0.005	0.867
Norway									
$p = 1$	–1.388*	–1.259*	1.4823	150.99*	0.778	0.635	0.101	0.237	0.368*
$p = 2$	–0.8696	–0.707*	2.0045*	99.134	0.666	0.548	0.090	0.024	0.867
$p = 3$	**–0.877***	**–0.698***	**2.0776***	**100.54***	**0.607***	**0.542***	**0.090***	**0.006***	**0.681**
$p = 4$	–0.8202	–0.6407	2.0462	94.25	0.687	0.568	0.092	0.031	0.562*
$p = 5$	–0.8383	–0.6582	2.0186*	95.67	0.679	0.561	0.092	0.015	0.624
$p = 6$	–0.871*	–0.6909	2.0430	98.60	0.673	0.549	0.091	0.016	0.686

Source: Authors' estimation.

Table 4

The Results of Estimation of Average Values of Unemployment Rate, the Volatility and Logit Specification Parameter for Determining Transitional Probabilities for Both Regimes

Country	Regime 1				Regime 2			
	Coefficient	Stand.error	z-statistics	p-value	Coefficient	Stand. error	z-statistics	p-value
Poland								
μ_r	18.3315	0.2039	89.9061	0.0000	8.9430	0.1631	54.8192	0.0000
$\log(\sigma_r)$	0.4995	0.0988	5.0550	0.0000	0.5526	0.0709	7.7943	0.0000
δ_{r1}	5.1601	1.3076	3.9463	0.0001	–5.4102	1.1983	–4.5150	0.0000
σ_r	1.6478				1.7377			
Bulgaria								
μ_r	15.0610	0.4249	35.4487	0.0000	8.7765	0.2450	35.8214	0.0000
$\log(\sigma_r)$	1.0496	0.0814	12.8938	0.0000	0.6936	0.0722	9.6106	0.0000
δ_{r1}	4.0224	0.8033	5.0074	0.0000	–4.2906	0.7733	–5.5486	0.0000
σ_r	2.8566				2.0009			
Slovakia								
μ_r	18.5475	0.1259	147.3233	0.0000	12.6370	0.1687	74.9300	0.0000
$\log(\sigma_r)$	–0.0556	0.0983	–0.5663	0.5712	0.6554	0.0620	10.5792	0.0000
δ_{r1}	5.0594	1.3499	3.7480	0.0002	–5.4480	1.1792	–4.6201	0.0000
σ_r	0.9459				1.9260			
Latvia								
μ_r	12.998	0.446	29.144	0.000	10.738	0.135	79.577	0.000
$\log(\sigma_r)$	1.527	0.067	22.915	0.000	0.062	0.091	0.685	0.493
δ_{r1}	4.270	0.774	5.514	0.000	–4.054	0.799	–5.076	0.000
σ_r	4.606				1.064			
Lithuania								
μ_r	14.4919	0.2345	61.8058	0.0000	7.4324	0.2487	29.8861	0.0000
$\log(\sigma_r)$	0.8687	0.0681	12.7605	0.0000	0.7639	0.0798	9.5675	0.0000
δ_{r1}	–4.2968	0.7702	–5.5791	0.0000	4.0691	0.7970	5.1054	0.0000
σ_r	2.3837				2.1465			
Ukraine								
μ_r	9.8874	0.1396	70.8420	0.0000	7.2345	0.0772	93.7375	0.0000
$\log(\sigma_r)$	0.1841	0.0747	2.4662	0.0137	–0.3964	0.0769	–5.1532	0.0000
δ_{r1}	4.0784	0.7652	5.3301	0.0000	–3.7668	0.6341	–5.9401	0.0000
σ_r	1.2022				0.6727			
Bulgaria								
μ_r	12.2578	0.2448	50.0646	0.0000	6.4203	0.1495	42.9452	0.0000
$\log(\sigma_r)$	0.9174	0.0681	13.4692	0.0000	0.2890	0.0792	3.6504	0.0003
δ_{r1}	–4.2733	0.7723	–5.5335	0.0000	4.0931	0.7933	5.1596	0.0000
σ_r	2.5028				1.3350			
Hungary								
μ_r	10.7178	0.0986	108.7315	0.0000	6.5833	0.0873	75.4201	0.0000
$\log(\sigma_r)$	–0.3665	0.1086	–3.3745	0.0007	0.0076	0.0578	0.1323	0.8948
δ_{r1}	3.8636	0.8850	4.3657	0.0000	–5.2016	1.0526	–4.9415	0.0000
σ_r	0.6932				1.0077			
Romania								
μ_r	8.048	0.097	83.172	0.000	6.617	0.055	120.634	0.000
$\log(\sigma_r)$	–0.533	0.115	–4.623	0.000	–0.439	0.060	–7.307	0.000
δ_{r1}	4.638	1.468	3.159	0.002	–5.322	1.165	–4.567	0.000
σ_r	0.587				0.645			
Norway								
μ_r	4.4109	0.0484	91.2249	0.0000	3.2510	0.0385	84.4551	0.0000
$\log(\sigma_r)$	–1.2078	0.1081	–11.1752	0.0000	–0.8843	0.0630	–14.0416	0.0000
δ_{r1}	3.7801	0.8298	4.5555	0.0000	–4.4401	0.7515	–5.9081	0.0000
σ_r	0.2989				0.4130			

Source: Authors' estimation.

Table 4 represents the estimates of average values of unemployment rate in each regime, the estimates of the volatility of both regimes and the estimates of logit specification parameter for determining transitional probabilities. We also represented the corresponding standard errors, *z*-statistics and *p*-values for testing the statistical significance of the estimated parameters. We obtained the significant differences in the means and volatilities for both regimes for all countries, as well as the significance of the transition parameters and the regime probabilities.

For all countries, we received one regime with high level of unemployment rate and the second one with relatively low unemployment level. Two levels that characterized different regimes are different for various countries. There are distinct differences between them, as well as between volatilities (σ_r^2) of fluctuations around average level in each regime. Otherwise, for some countries, the volatility of the regime with higher unemployment is higher (Latvia, Lithuania, Estonia, Ukraine, Bulgaria, Romania), whereas in other countries, the regime with low unemployment is more volatile (Poland, Slovakia).

For Poland, we obtained two distant regimes with the significant difference between means (18% and 9% for unemployment respectively). The volatilities in these regimes are approximately equal to 1.6% and 1.7%. A similar situation is observed in Bulgaria, where the difference in unemployment rates in different regimes exceeds 6% (15% in the first mode and 8.8% in the second), the volatility of the first regime is slightly higher (2.9% in the first and 2% in the second). In Slovakia, the difference in unemployment among different regimes is also more than 6%, while in this country we observe the highest its level among the new EU member states (18.5% in the first regime and 12.6% in the second). The volatilities of regimes are estimated as 0.94% and 1.92%.

In the Baltic countries, although we observed the similar behavior dynamics of unemployment at first glance, the modeling showed significant differences in the structure of this dynamics. In Latvia, both regimes are characterized by high levels (12% and 10%), besides the volatility of the unemployment fluctuations in high-level mode is high (4.6%). For Lithuania and Estonia, the differences between unemployment rates in two regimes are more significant. We have discovered the higher values for Lithuania (14% for 1 regime and 7.4% for the second) comparing to Estonia (12% for the first and 6% for the second). Unemployment in Hungary is relatively low (10.7% and 6.5% for 1 and 2 regimes) and stable (volatility 0.69% and 1% for 1 and 2 regimes). We obtained completely different results for Romania. There are steady trends in this country, and the difference in unemployment rates in different regimes is negligible (8% and 6.6%). Besides, the volatility is small.

In Ukraine, the situation is different from other countries and it is not similar to any of the EU countries. The average unemployment rate in both regimes (9.9% and 7.2%) is relatively low compared with EU – new member countries and its volatility (1.2 and 0.67) is low. Note that in the countries with traditionally low unemployment, in particular in Norway (the same results have been obtained for Sweden and Denmark) both regimes are characterized by low unemployment rate and low volatility.

The analysis of the transition probabilities from one regime to another (Table 5) implied that for most countries we estimated the higher probabilities of remaining in the previous regime of behavior, while the probability of transition from high unemployment to low or vice versa is low. These results showed the inelasticity of the unemployment rate and its certain stability, in particular due to the hysteresis of unemployment and its influence on the dynamics of the natural unemployment rate.

Table 5

The Results of Regime Transition Probabilities Estimation

Country	The probability of being in regime 1 (high unemployment) given that the system was in regime 1 during the previous period	The probability of transition to regime 2 (low unemployment) from regime 1 (high unemployment)	The probability of transition to regime 1 (high unemployment) from regime 2 (low unemployment)	The probability of being in regime 2 (low unemployment) given that the system was in regime 2 during the previous period
Poland	0.9943	0.0057	0.0045	0.9955
Hungary	0.9794	0.0206	0.0055	0.9945
Slovakia	0.9937	0.0063	0.0043	0.9957
Romania	0.1390	0.8610	0.0370	0.9630
Bulgaria	0.9824	0.0176	0.0135	0.9865
Ukraine	0.9833	0.0167	0.0226	0.9774
Lithuania	0.9866	0.0134	0.0168	0.9832
Latvia	0.9865	0.0135	0.0175	0.9825
Estonia	0.9863	0.0137	0.0164	0.9836
Norway	0.9777	0.0223	0.0117	0.9883

Source: Authors' estimation.

We evaluated that the probabilities of the transition from low unemployment to high are greater for Ukraine and the Baltic countries, while for the rest of the countries (Poland, Hungary, Slovakia, Bulgaria, and Norway) there are greater probabilities of transition from high to low unemployment rate. The exception is observed only for Romanian labor market. Here the probability of being in regime with relatively low unemployment is greater and does not depend on the original regime of labor market. The transition probability from high to low unemployment is 0.86 and the probability of remaining in the low unemployment state is 0.96. Therefore, the probability of remaining in a regime with a higher level of unemployment given that the system was in this regime during the previous period is only 0.14.

The average expected durations in each regime for various countries are also different (Table 6). In particular, for Poland, Hungary, Slovakia, Romania, Bulgaria, Norway, these values are significantly greater for a low unemployment regime comparing to a high unemployment regime, while for the Baltic States and Ukraine, on the contrary, the expected duration in regime with high unemployment is greater. Noted that in Poland and Slovakia there were longer declines in unemployment that in particular were caused by European integration processes. At the same time, in Latvia, Lithuania, Estonia, Hungary and Bulgaria due to the crisis in 2008, the unemployment rate increased significantly and even slightly exceeded the level observed before accession to the EU, indicating the instability of the labor market of these countries to significant external shocks.

Table 6

The Average Expected Duration of Unemployment in Each Regime (in months)

Country	Expected durations in regime 1 (high unemployment)	Expected durations in regime 2 (low unemployment)
Poland	17.5777	22.4827
Hungary	4.8386	18.2579
Slovakia	15.8959	23.3866
Romania	0.1614	2.7534
Bulgaria	5.6334	7.4092
Ukraine	6.0537	4.4412
Lithuania	7.4610	5.9030
Latvia	7.3057	5.7955
Estonia	7.2603	6.0269
Norway	4.4221	8.5872

Source: Authors' estimation.

Table 7

The Estimation Results of the Markov Regime Switching Models for Unemployment Growth Rate

Parameter	Poland	Hungary	Slovakia	Bulgaria	Ukraine	Lithuania	Norway
μ_1	0.4520	0.2426	0.4851	0.3830	0.2962	0.6921	0.1182
	(0.0690)	(0.0483)	(0.0649)	(0.0430)	(0.0530)	(0.1231)	(0.0264)
μ_2	–0.1814	–0.1103	–0.1500	–0.2604	–0.0771	–0.2044	–0.0938
	(0.0258)	(0.0208)	(0.0260)	(0.0275)	(0.0279)	(0.0474)	(0.0259)
δ_{11}	0.8090	0.9034	1.0569	1.3539	1.3555	0.9600	–0.5260
	(0.3934)	(0.4480)	(0.4697)	(0.3373)	(0.5526)	(0.4176)	(0.4377)
δ_{21}	–2.4065	–2.0720	–2.9846	–2.0884	–2.8866	–2.6489	0.7682
	(0.3302)	(0.3335)	(0.5080)	(0.3118)	(0.6947)	(0.4941)	(0.4416)
σ	0.2571	0.1638	0.2658	0.2589	0.2125	0.4057	0.1185
p_{11}	0.6919	0.7116	0.7421	0.7948	0.7950	0.7231	0.6285
p_{12}	0.3081	0.2884	0.2579	0.2052	0.2050	0.2769	0.3715
p_{21}	0.0827	0.1118	0.0481	0.1102	0.0528	0.0661	0.3169
p_{22}	0.9173	0.8882	0.9519	0.8898	0.9472	0.9339	0.6831
d_1	3.2456	3.4679	3.8774	4.8724	4.8789	3.6117	2.6921
d_2	12.0951	8.9408	20.7777	9.0717	18.9322	15.1382	3.1559

Source: Authors' estimation.

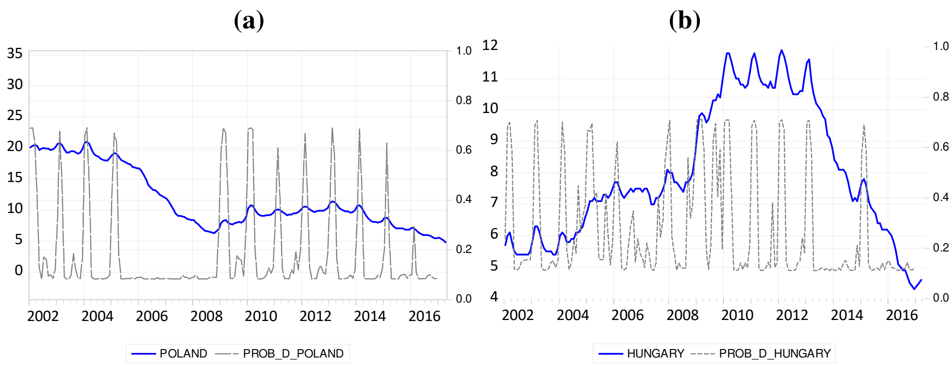
We also estimated the Markov regime switching models for growth rate of unemployment rate. The results of parameters estimation for different regimes are presented in the Table 7. The standard errors are given in parentheses.

By studying the models for times series of unemployment growth rate, we obtained similar results for various countries. In particular, the first regime is characterized by positive changes in unemployment, and hence its growth, while the second regime is characterized by negative changes, and therefore, caused the decline in unemployment. However, the values of the coefficients are different in absolute value. For Latvia, Lithuania and Estonia, the regime of positive changes is characterized by relatively higher values, while the regime for reducing unemployment is more important for Poland, Slovakia and Bulgaria. For all countries of EU and Ukraine, the probability of remaining in the original state is much greater than for changing it. The highest probabilities of remaining in increasing regime (approximately 0.8) were obtained for Ukraine and Bulgaria. The probabilities of remaining in decreasing regime are also high for all countries. At the same time, note that for EU members in Eastern Europe the declining regime is more stable than increasing regime. However, for Norway, both regimes are characterized by roughly equal transition probabilities.

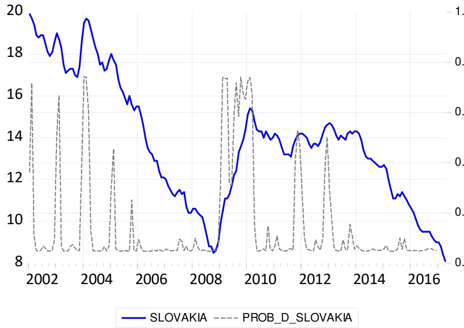
The constructed models allow us to predict the one-step ahead predicted probabilities of being in different regimes for each period. In Figure 2 we displayed the one-step ahead predicted probabilities of being in increasing regime of unemployment (right scale), along with actual unemployment rates (left scale). Note that in Ukraine, comparing to other EU members, the probability of unemployment growth is often very high, indicating the instability of the national economy and the labor market.

F i g u r e 2

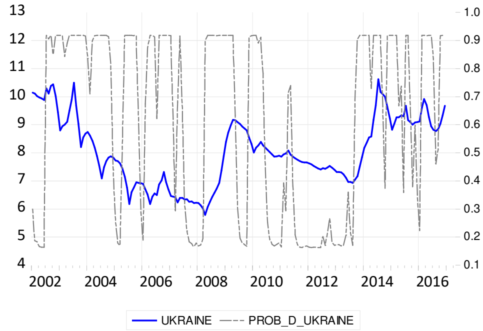
The One-step Ahead Predicted Probabilities of Being in Increasing Regime of Unemployment of (a) Poland; (b) Hungary; (c) Slovakia; (d) Ukraine; (e) Lithuania; (f) Latvia; (g) Estonia; (h) Bulgaria; (i) Romania during 2000 – 2017



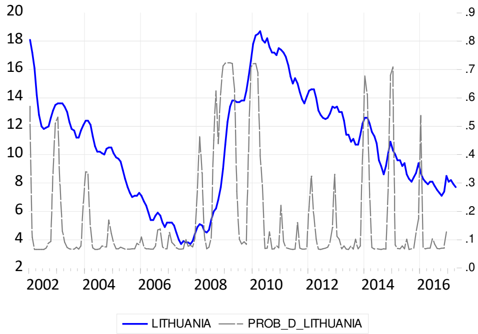
(c)



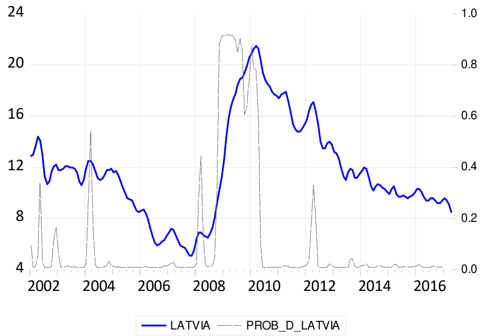
(d)



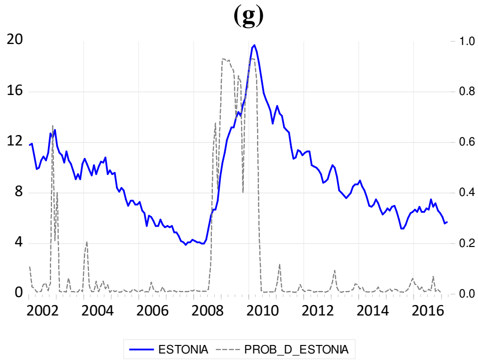
(e)



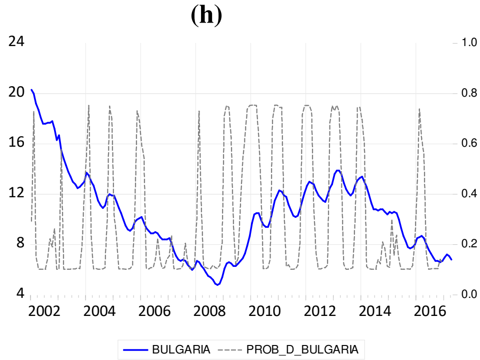
(f)



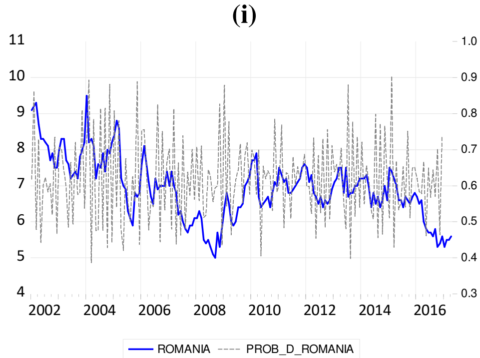
(g)



(h)



(i)



Source: Authors' evaluation.

The results showed that Poland, Estonia and Latvia exhibited very low predicted probability to be in increasing unemployment regime just after 2004 when these countries joined European Union. In contrast, Slovakia and Hungary in spite of becoming the EU members at the same 2004 did not reveal immediate significant decrease in probability of being in unfavorable regime. In these countries a risk to shift to high unemployment rate remained and frequently appeared after 2004 that later caused long period of high unemployment after 2008, when the crisis occurred, and the start of recovery could be observed only in 2013. In Lithuania the association with European Union in 2004 helped to decrease the unemployment rate considerably. However, 2008 crisis significantly affected the probability of switching labor market to unfavorable mode and in 2014, when almost all other countries recovered, the risk of high unemployment appeared again.

Bulgaria and Romania joined EU in 2007 just before the crisis and didn't have time to stabilize their labor market before great recession caused by 2008 financial crisis. These countries exhibit persistence of high probability to switch to unemployment increasing regime. The problems in educational environment could be a source of high unemployment in some countries. Particularly, in Romania, the number of graduates, the number of teaching staff and the number of faculties caused high level of unemployment among workers with higher education who cannot quickly satisfy labor market requirements and integrate into the workforce especially under innovation shocks (Simionescu and Naroș, 2019). In Ukraine, comparing to other EU members, the probability of unemployment growth is often very high, indicating the instability of the national economy and its labor market.

Conclusions

Over the past decade, unemployment rate in Eastern Europe has undergone dramatic changes. We can observe various asymmetric influences as positive processes that were associated with accession of countries to the European Union as well as the impact of strong sudden negative economic disturbances and further gradual economic recovery on the labor markets. In addition, the labor market of Ukraine demonstrates the effect of destabilization processes associated with social upheavals and military actions by the border with Russia. European integration processes had a positive impact on employment in the new member states. Regardless of their previous dynamics, the unemployment rate in Poland, Hungary, Slovakia, Latvia, Lithuania, Estonia, Bulgaria, Romania declined significantly after joining the European community, labor spheres showed positive trends for recovery and reducing the natural long-term unemployment rate. However, the crisis that had an impact on the European labor markets at the end of 2008 led to a sharp increase in unemployment and significant joblessness in all countries. After-crisis processes in the labor markets of Eastern Europe occurred very differently. The distinct dynamics of unemployment, especially after 2009, revealed as the recovery of the labor market could lag recoveries in general economic activity and showed a different degree of hysteresis in unemployment for various countries.

To analyze the dynamics of unemployment rate we constructed econometric regression models with nonlinearities that arose due to discrete changes in modes. We developed Markov switching model that allowed capturing the regularities by modeling the asymmetry in the unemployment rate during contractionary and expansionary states of the labor market. We evaluated two regimes of unemployment behavior that were associated with high and low unemployment levels and estimated the transition probabilities of regime change and average expected durations of being in each regime. The comparison of mean and volatility of different regimes and the one-step ahead predictions of the regime probabilities for different countries revealed the labor market specifics of each country and showed differences in the flexibility of their reactions to changing economic environment. The results of the modeling showed that despite the relatively low unemployment rate in Ukraine in comparison with its average European level, the probability of being in increasing regime is often very high in comparison with the EU member states that indicated the instability of the Ukrainian labor market and the advantages of the European integration.

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