European unemployment nonlinear dynamics over the business cycles: Markov switching approach

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Abstract: The dynamics of European unemployment showed considerable fluctuations and asymmetric behaviour during business cycles over the past decade. The dynamic pattern of unemployment rate demonstrated the significant differences for different countries during its growth and decline periods. To describe the differences in dynamic properties of unemployment rate in different countries and economic situation, we developed the Markov switching autoregressive models with time-varying probabilities of transition between behaviour regimes. The results revealed that the unemployment rate in EU countries during 2000–2016 behaved asymmetrically over the business cycle. Therefore, we got different processes for describing unemployment dynamics in each phase of the economy.

Keywords: unemployment rate; regime switching model; Markov chain; autoregression; labour market; econometric modelling; asymmetry.

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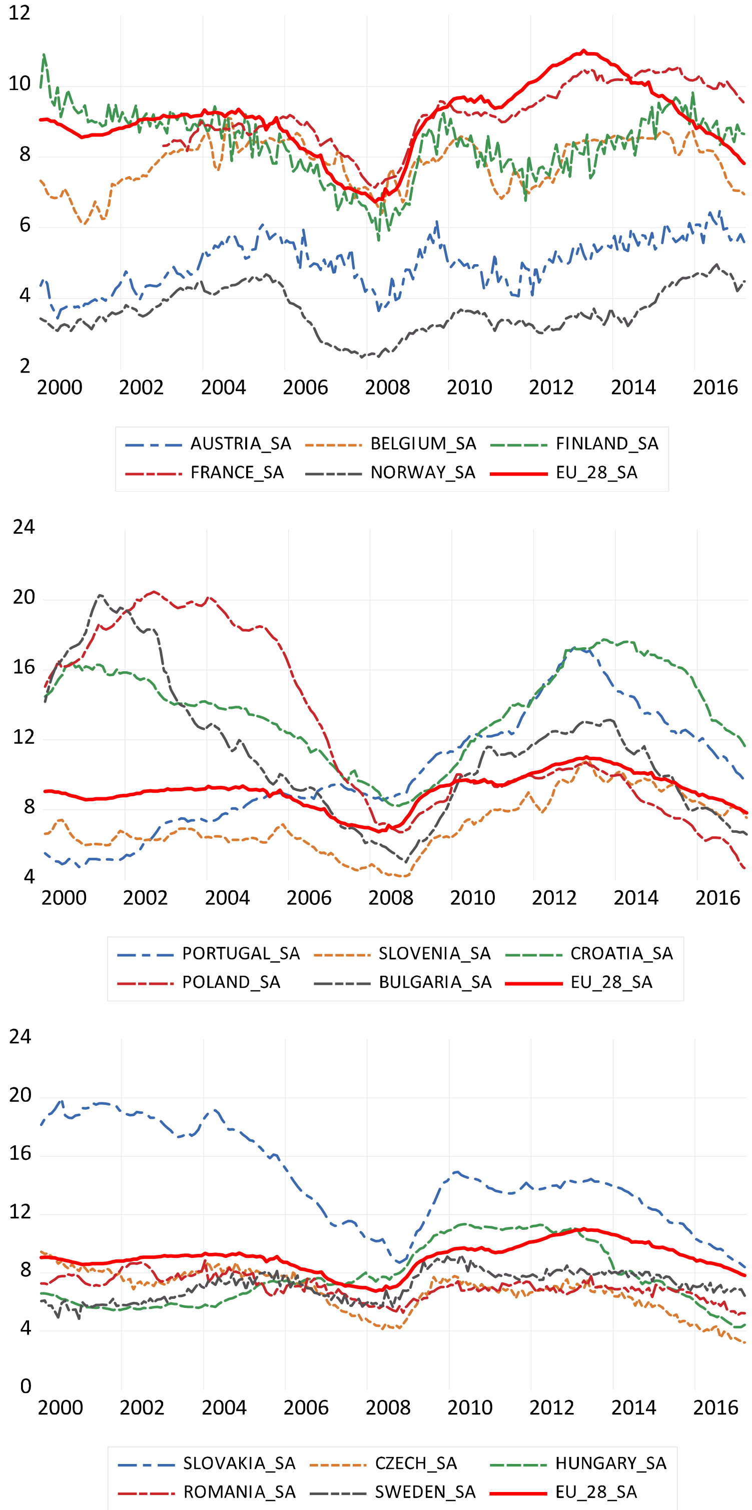
1 Introduction

The dynamics of unemployment in European countries has shown considerable fluctuations over the past decade. At the same time, we observe significant differences in its behaviour for different countries. Not only average levels and variations of unemployment fluctuations differ for different periods, but also the dynamic properties of its behaviour, the duration of growth and decline periods, the turning points and changes in its dynamics, values of unemployment rate (UR) have been changed. Significant differences are inherent characteristics of developed European countries as well as the countries that joined the European Union later. Strong negative perturbations of economic environment, which occurred at the end of 2008, have led to an increase in unemployment in all the EU countries. However, the response effects to these disturbances had different amplitudes and duration of the unemployment fluctuations for different countries, showing the peculiarities of individual labour markets (Figure 1). Differences in the level of unemployment and its dependence on the specifics of the region show strong polarisation, especially in the post-crisis period between 2007 and 2013 (Beyer and Stemmer, 2016).

The level of unemployment depends on many factors. Besides, the reactions of the labour market indicators to changes of these factors in different countries are different. The demographic and educational situation, changes in the age structure of the population (Biagi and Lucifora, 2008), changes in social norms and preferences of participation in the labour market (Balleer et al., 2014) are important factors in the long run. Differences of UR in different countries, to some extent, are due to differences in the labour participation of women, which is significantly different for developed countries (Ukil, 2015; Mishra and Smyth, 2010) and developing countries (Tam, 2011; Tsani et al., 2013). A wide variety of economic and social factors, including economic growth, education, and social norms has a significant impact (Verick, 2014). Other important factors are international migration (Tudorache, 2006; Christofides et al., 2007) and historical circumstances (Gaddis and Klasen, 2014). In addition to demographic and cyclical factors, scientists demonstrate the importance of educational levels, social welfare programs (Kennedy and Hedley, 2003; Katay and Nobilis, 2009), pay equivalence, cohesion and competitiveness (Galbraith and Garcilazo, 2010); the health of the nation (Kalwij and Vermeulen, 2008), that are different for different European countries.

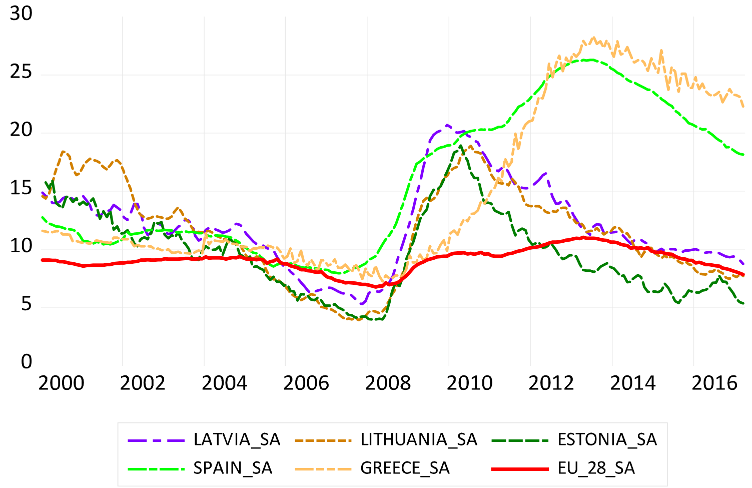
The long-term trends explain only some changes in the labour market, the other changes are due to cyclical factors, in particular recessions (Zandweghe, 2012). Researchers suggest that economic activity in Europe is countercyclical (Nucci and Riggi, 2016) and the level of unemployment can be in some relationship with labour force participation rate during the fluctuations of the economy. Although scientists argue that in Europe there is a correlation between the coefficient of labour participation and changes in cyclical unemployment (Elsby et al., 2013; Petrongolo and Pissarides, 2008), however, the direction and causality of such a relationship, as well as the sign of correlation, can be different for different countries and depends on the state of the economic environment. In some European economies, economic activity and unemployment are sensitive to changes in wages that arise from changes in income taxes and transfers, but the elasticity of such changes is low (Yuldashev and Khakimov, 2011; Senaj et al., 2016).

Figure 1 Dynamics of UR in European countries during 2000–2017 (see online version for colours)



Source: Data from EUROSTAT database, elaborations of the authors

Figure 1 Dynamics of UR in European countries during 2000–2017 (continued) (see online version for colours)



Source: Data from EUROSTAT database, elaborations of the authors

Due to the hysteresis of unemployment, the recovery in the labour market after recession can reveal lag recovery in comparison to general economy processes. Thus, the dynamics of labour market indicators can show behavioural patterns that are not consistent with the official peaks and troughs of the business cycle. These lags are caused by the need to restore the unemployed, to reduce the inefficient workforce distribution that occurs during prolonged recessions (Koenders and Rogerson, 2005), more flexible usage of the existing workforce (Schreft and Singh, 2003) and the spread of technology that creates greater incentives for investment in job search or human capital (Oliskevych, 2015).

The aim of our paper is to investigate UR dynamics by discovery and comparison of recovery and contractionary regimes in its behaviour for different European countries. We conduct the econometric analysis using switching models that are sufficiently flexible to describe different types of behaviour for different periods.

2 Literature review

The idea of describing the fluctuations of the economy in different modes or stages belongs to Hamilton (1989) who developed the Markov switching (MS) model to capture the regularities in the data that revealed during the business cycle. The MS model allows the time series to be in contractionary and expansionary regimes with some probabilities and to explain the asymmetry of data observation in each of these states.

Significant gaps in behaviour associated with events such as the financial crisis were found in many economic time series (Jeanne and Masson, 2000; Hamilton, 2008), as well as in government policy (Davig, 2004). The apparent tendency of many economic variables to behave quite differently during economic downturns, when the production is used insufficient, rather than their long-term growth tendency that governs economic dynamics has a particular interest for economists (Chauvet and Hamilton, 2006).

Sharp changes are a common feature of financial data. Abrupt changes in fundamentals are reflected in asset prices (Ang and Bekaert, 2002; Garcia et al., 2003). Leccadito and Veltri (2015), on the basis of on the study of stock market firms during

1980–2011, argued that abnormal earnings and other financial variables can be described by regime-switching dynamics. They built a regime-switching version of the Ohlson model for forecasting market prices. Dai et al. (2007) conducted a decomposition of expected returns on risk factors and regime shifts for the USA. Treasury zero-coupon bond yields showed the importance of priced, state-dependent, regime-shift risks in capturing the time variations in expected excess returns. Thus, the asymmetry in the cyclical behaviour of interest rates was found out. Shen et al. (2016) substantiated the existence of two regimes: the hawk regime and the dove regime in the central bank policy, that more concerned about inflation than output gap, and built a thresholds index that divided the sample into two modes with high and low prices on the basis of inflation and asset growth rate. They determined two types of monetary policy - low yield and high inflation and vice versa.

Pelletier (2006) used a switching model with Markov chain to decompose a covariance matrix on correlations and standard deviations to construct multi-step forward conditional expectations and improved the dynamic conditional correlation model. Cai (1994) developed a Markov model of switching-regime ARCH. Billio and Sanzo (2015) proposed a new approach to causality testing for models that take into account regime changes according to multi-dimensional Markov chains. They investigated the relationship between financial and economic cycles in the USA and used the bivariate MS model to predict aggregate economic activity. Lanne et al. (2010) showed that structural vector autoregressive (SVAR) analysis and Markov regimen switching (MS) could be used to identify structural shocks in the event that the covariance matrix is varied and characterised by different regimes.

Regime switching models are used to model various processes, including spot electricity prices (Weron et al., 2004); oil prices, output, consumer prices and a short-term interest rate (Herwartz and Lütkepohl, 2014). Alizadeh et al. (2015) investigated the importance of oil and oil products transportation in the energy supply chain during 2005–2013. They developed the regime switching GARCH specification and bivariate Markov regime switching GARCH model, defined different market conditions and showed that the tanker freight market is characterised by different regimes with high and low volatility. Ghiani et al. (2014) built MS model with three regimes for studying monetary aggregates and Federal Funds rate. They revealed the cointegration relationships between interest rate, inflation, unemployment and the money supply. Camacho (2011) showed that US GDP is characterised better as trend stationary MS process than as having a (regime-dependent) unit root, and investigated the persistence of the dynamic response of output to a random disturbance.

Differences between phases are also observed for the labour market processes (Kolot, 2012). Boldin (1993) explored various business cycle dating methodologies and by means of MS model of the UR found that a recovery regime occurred for several quarters after the end of the official recession. Hamilton (2008) reached a similar conclusion, suggesting that movements in the labour market are closely aligned with the broad economic activities phases. Deschamps (2008) estimates a MS model of the UR using the Markov Chain Monte Carlo estimator. His results indicated that labour market contractions, which are longer than NBER recessions, are the rule rather than the exception. Cevik and Dibooglu (2013) investigated non-linearity of the US UR by using a regime-switching unit root test and showed that the effects of negative shocks on unemployment are long persistent in support of hysteresis hypothesis testifying the loss of valuable job skills in workers during recession periods. Netšunajev and Glass (2017) investigated the transmission mechanism of the effects of local and foreign uncertainty shocks, related to economic policy, on employment in two largest economies – the USA and Europe. They developed Bayesian MS-SVAR model and exposed the influence of foreign shocks on the Euro zone and the absence of such an influence on the USA. An excess of both local and foreign uncertainty shocks was established during periods of fluctuations with greater volatility. Juhn et al. (2002) developed a dynamic factor model with Markov switches to study the fluctuations of US UR during business cycles. They conduct strong evidence of the existence of common factors and the switch between high and low unemployment regimes. Lee and Chang (2008) discovered the hysteresis of unemployment in Europe, high long-term effects of structural change that are persistent and caused nonlinear behaviour common forces that generates this nonlinear behaviour in European URs. Netsunajev (2013) studied the effects of technological shocks on the work hour's length with MS structure in classical SVAR analysis. Caporale and Gil-Alana (2007) built the US UR model that takes into account asymmetry and long memory, used fractional integration processes and nonlinearities simultaneously which was combined with a nonlinear function of variables that determined the labour demand including real oil prices and real interest rates.

Caner and Hansen (2001) developed an unrestricted two-regime threshold autoregressive (TAR) model with an autoregressive unit root for the modelling of US monthly UR using both asymptotic and bootstrap-based tests. They found the nonlinearity (thresholds) and non-stationarity (unit roots) and substantiated the two-parameter empirical process that converges weakly to a two-parameter Brownian motion. Klinger and Weber (2016) conducted a new approach that used MS unobserved components for analysis of hysteresis of unemployment and showed the asymmetry of unemployment in Germany in relation to the business cycle. Schwartz (2012) investigated the processes in the labour market during the business cycle and substantiated that existence of a relationship between the UR and the average duration of unemployment emerged over the last four decades from December 1972 to December 2008. Using MS models, he focused on the UR, the average duration of UR, unemployment benefits and the exhaustion rate of regular unemployment insurance.

The main findings of previous scientific empirical works, dedicated to investigation of properties of labour market indicators in short and long run, are summarised in Table 1. For the past decades, scientists discuss the existence of unemployment hysteresis and its impact on long run tendencies in labour force participation as well as asymmetric behaviour of UR during the business cycles, nonlinearities and reaction of labour market on positive and negative shocks.

However, despite many issues, investigated by scientist around the world, there are a lot of questions concerning exploration of common forces and differences in dynamics of unemployment in pool of different European countries especially the countries that joined EU during the last decades. The investigation of different behaviour of UR and labour force participation during the contractionary and expansionary phases of business cycles, properties of recovery periods after crisis and its duration in each separate country as well as in comparison with average tendencies in Europe are among the remaining open issues.

Table 1 Summary of previous empirical works

Name of researchers	*Year where research was conducted*	*Countries, included in the sample*	*Outcome of the results*
M. Chauvet, J. Hamilton	2006	USA	Indicate that economic variables behave quite differently during economic downturns, when the production is used insufficient, rather than their long-term growth tendency that governs economic dynamics
G. Caporale, L. Gil-Alana	2007	USA	Suggest that the unemployment rate can be specified in terms of a fractionally integrated process; find evidence of a long-memory component consistent with a hysteresis; suggest that any suitable model should include business cycle asymmetries
M. Franchi, J. Ordonez	2008	European Union	Analyse the hypothesis of hysteresis in Europe; indicate smooth transition trend-stationarity in European unemployment rates around highly persistent structural changes; suggest the existence of common force that generates nonlinear behaviour
J. Hamilton	2008	USA	Suggest that movements in the labour market are closely aligned with the broad economic activities phases and business cycles
C. Lee, C. Chang	2008	14 major OECD countries	Re-examine the hypothesis of unemployment hysteresis, provide significant evidence that unemployment rates are stationary; discover several critical economic affairs which cause unemployment rates in OECD countries to fluctuate significantly
J. Schwartz	2012	USA	Find existence of a relationship between the unemployment rate and the average duration of unemployment; build Markov switching models; indicate that labour market recoveries has lags in comparison to broad economic activity
W. Zandweghe	2012	USA	Suggest that long-term trends explain only part of changes in the labour market, the other part due to cyclical factors, in particular recessions
M. Elsby, B. Hobijn, A. Sahin	2013	OECD countries	Find the evidence of correlation between the labour force participant participation and changes in cyclical unemployment; reveal that fluctuations in both inflow and outflow rates contribute substantially to unemployment variation within countries
E. Cevik, S. Dibooglu	2013	USA	Analyse the behaviour of unemployment using linear and regime switching unit root tests; suggest that unemployment has regime dependent properties
T. Bayat, S. Kayhan, A. Kocyigit	2013	Turkey	Investigate the asymmetric behaviour of unemployment rate during 1923–2011; build Markov Switching model; indicate that the unemployment rate behaves asymmetrically and its structure is nonlinear

Source: Literature review summarised by authors

Table 1 Summary of previous empirical works (continued)

Name of researchers	*Year where research was conducted*	*Countries, included in the sample*	*Outcome of the results*
N. Gaston, G. Rajaguru	2015	Australia	Estimate the Markov-Switching SVAR model to examine the relationship between unemployment and labour force participation; find that the labour market switches between periods of low unemployment and high participation, prolonged periods of relative stability and short, sharp periods of high unemployment and low participation
O. Shalari, E. Laho, A. Gumeni	2015	Albania	Employ fractionally integrated time series model to account for long-memory in the unemployment rate; discover the presence of asymmetry; prove nonlinearities as inherent characteristics; suggest that negative shocks have bigger impact on the unemployment rate than positive shocks
M. Billio, S. Sanzo	2015	USA	Proposed a new approach to causality testing for models that take into account regime changes according to multi-dimensional Markov chains
R. Beyer, M. Stemmer	2016	Europe	Discover the convergence for distribution of regional unemployment rates in Europe prior to the recent crisis as well the strong polarisation afterwards that can be attributed to both country and region-specific fluctuations
F. Nucci, M. Riggi	2016	Euro area	Find evidence that cyclical developments determined the behaviour of labour market participation in the post-2007 period and labour force participation in the euro area exhibited countercyclical features
M. Senaj, Z. Siebertova, N. Svarda, J. Valachyova	2016	Slovakia	Estimate the probability model for participation in labour force; explore that economic activity and unemployment are sensitive to changes in wages during the business cycles that arise from changes in income taxes and transfers
C. Shen, K. Lin, N. Guo	2016	China	Estimate switching regression model; substantiate the existence of two regimes: the hawk regime and the dove regime in the monetary policy
S. Klinger, E. Weber	2016	Germany	Conduct a new Markov-switching unobserved components approach to analyse the hysteresis of unemployment, indicate the asymmetry over the business cycle
A. Netunayev, K. Glass	2017	USA and Euro area	Deploy Bayesian Markov-switching structural vector autoregressive model identified via heteroscedasticity; indicate weaker spillovers of local and foreign uncertainty shocks on unemployment during periods of greater volatility

Source: Literature review summarised by authors

In our paper, we examine the UR for different European countries during 2000–2017 by the MS autoregressive model in order to describe the different behaviour in the contractionary and expansionary regimes and to emphasise the asymmetry in its movements. We investigate the properties of switching in the UR behaviour in each country, the probabilities of relative stability for existing state as well as transition probability of moving in opposite direction according to change in general economic activity. Our modelling takes into account lags in responses that characterise labour market and indicate the dependence of specific labour market in separate country on average behaviour of EU unemployment. We also indicate the similarities between some countries as well as make comparison of their particularities.

3 Methodology

The basic dynamic switching model is a model based on the first order autoregressive model (Hamilton, 2008)

$$y_t = a(r_t)\psi y_{t-1} + \varepsilon_t \tag{1}$$

with $\varepsilon_t \sim N(0, \sigma^2)$, where r_t is a random variable that as a result of the influence of the economic environment disturbance, structural and institutional changes can reach the values $r_t = i$, $i = 1, \ldots, R$. Assume that the r_t is the realisation of a two-state Markov chain with

$$\text{Prob}\left(r_t = j \middle| r_{t-1} = i, r_{t-2} = k, \ldots, y_{t-1}, y_{t-2}, \ldots\right) = \text{Prob}\left(r_t = j \middle| r_{t-1} = i\right) = p_{ij} \tag{2}$$

We cannot directly observe r_t. Therefore, we base our conclusions about state changes only by means of the observed behaviour for y_t. Condition (2) assumes that the probability of staying in a certain mode in the current period depends only on the mode in which the system was in the previous period, and no more earlier information affects this probability.

In the general case where there are R states, the transition probabilities can be expressed in a matrix as (Brooks, 2008)

$$P = \begin{pmatrix} P_{11} & P_{12} & \ldots & P_{1R} \\ P_{21} & P_{22} & \ldots & P_{2R} \\ \ldots & \ldots & \ldots & \ldots \\ P_{R1} & P_{R2} & \ldots & P_{RR} \end{pmatrix} \tag{3}$$

where P_{ij} is the probability of jumping from regime j to regime i. At any given period, the system have to be in one of the R states so

$$\sum_{j=1}^{R} P_{ij} = 1 \quad \forall i = 1, \ldots, R \tag{4}$$

A vector of current state probabilities is defined as

$$\pi_t = \left(\pi_1, \pi, \ldots, \pi_R\right) \tag{5}$$

where π_i is the probability that the variable y is currently in regime i. Hence, the probability that the variable y will be in a given regime next period is derived as

$$\pi_{t+1} = \pi_t P \tag{6}$$

The probabilities for s horizons are given by

$$\pi_{t+s} = \pi_t P^s \tag{7}$$

The general specification is the MS AR(1) model where the errors variance and the autoregression parameter are dependent on regime (Bergman and Hansson, 2005)

$$y_t = a(r_t) + \psi(r_t) y_{t-1} + \varepsilon_t \tag{8}$$

$\varepsilon_t | r_t \sim N(0, \sigma^2(r_t))$. Assuming the presence of two states, we use the transition matrix

$$P = \begin{pmatrix} p_{11} & 1 - p_{22} \\ 1 - p_{11} & p_{22} \end{pmatrix} \tag{9}$$

Then the full description of the probability distribution of y_t is determined by the variances of the Gaussian innovations $(\sigma_2)^2$ and $(\sigma_1)^2$, the autoregressive coefficients ψ_1 and ψ_2, the two intercepts a_1 and a_2, and the two state transition probabilities p_{11} and p_{22}. If $p_{22} = 1$, then the change of regime is deterministic and constant. Assuming $p_{22} < 1$, we can take into account the more general possibility of random changes. Model (4)–(5) with $p_{22} < 1$ allows us to describe the dynamics of an economic process that can change its behaviour and return to the previous regime. These changes in the regime can be caused by changes in the real sector of the economy, in monetary or fiscal policies, in migration, etc. Business cycles, economic and financial crises have a strong impact on the labour market and volatility of its indicators. Thus, an approach that takes into account switching modes is useful for describing the asymmetries in UR behaviour.

In more general case the MS model takes the p-order autoregressive form (Schwartz, 2012)

$$y_t = a(r_t) + \psi(r_t)(L) y_{t-1} + \sigma(r_t) e_t \quad \text{for } r_t = 0, 1 \tag{10}$$

where $\psi(r_t)(L)$ is a lag polynomial

$$\psi(r_t)(L) = \psi_1(r_t) + \psi_2(r_t) L + \ldots + \psi_p(r_t) L^{p-1} \tag{11}$$

$e_t \sim N(0, 1)$, $\sigma(r_t)$is the standard deviation. The random variable r_t describes the state of the economy, takes the value of zero in a contraction periods of labour market and the value of one in an expansion periods. In this model, all parameters including variation of residues can take different values depending on the regime.

Parameters of model (10)–(11) and probabilities (3) are estimated by the maximum likelihood using a Kalman type filter. Suppose $\Omega_t = \{y_t, y_{t-1}, \ldots, y_0\}$and $\theta = \{\alpha, \psi(L), P, \sigma\}$, where α, $\psi(L)$, σ are vectors that describe the parameter values for states 1, …, R. The probability of observing y_t conditional on $r_t = r (r = 0, \ldots, R)$ and Ω_{t-1} is

$$f(y_t | r_t = r, \Omega_{t-1}, \theta) = 1/\sigma(r) \quad \varphi\big((y_t - \mu(r))/\sigma(r)\big) \quad \text{for } r = 1, \ldots, R \tag{12}$$

where $\varphi(x) = 1 / (2\pi) \exp(-x^2 / 2)$ is the density of standard normal distribution.

Then, the probability of observing y_t given only Ω_{t-1} we can obtain by weighting the density function in each of the regimes by the one-step ahead probability of being in that regime $P(r_t = r \mid \Omega_{t-1}, \theta)$. Hence,

$$f\left(y_t \middle| \Omega_{t-1}, \theta\right) = \sum_{r=1}^{R} f\left(y_t \middle| r_t = r, \Omega_{t-1}, \theta\right) \cdot P\left(r_t = r \middle| \Omega_{t-1}, \theta\right) \tag{13}$$

The prediction regime probabilities we can get with the transition matrix

$$P\left(r_t = r \middle| \Omega_{t-1}, \theta\right) = \sum_{r=1}^{R} p_{jr}(t) \cdot P\left(r_{t-1} \middle| \Omega_{t-1}, \theta\right) \tag{14}$$

The probabilities of being in state r_{t-1}, given the information up to time t, is called filtered probabilities and are determined by Bayes' theorem and the laws of conditional probabilities. Thus, we have the filtering expressions

$$\begin{aligned} P\left(r_{t-1} = j \middle| \Omega_{t-1}, \theta\right) &= f\left(y_{t-1} \middle| r_{t-1} = j, \Omega_{t-2}, \theta\right) \\ &\quad \cdot P\left(r_{t-1} = j \middle| \Omega_{t-2}, \theta\right) \Big/ f\left(y_{t-1} \middle| \Omega_{t-2}, \theta\right) \end{aligned} \tag{15}$$

for $j = 1, \ldots, R$

where the terms in right-hand side of (15) is determined by (12)–(14) with one lag.

The full log-likelihood function is

$$\log L(\alpha, \psi, \sigma, \delta) = \sum_{t=1}^{T} \log \sum_{r=1}^{R} \frac{1}{\sigma(r)} \varphi\left((y_t - \mu)/\sigma(r)\right) \quad P\left(r_t = r \middle| \Omega_{t-1}, \delta\right) \tag{16}$$

The Markov property of the transition probabilities implies that the expressions on the right-hand side of (16) must be evaluated recursively. We maximise the function (16) with respect to $\theta = (\alpha, \psi, \sigma, \delta)$ using iterations based on the initial filtered probabilities or the initial one-step ahead regime probabilities.

In the case when the regime probabilities are constants they can be interpreted as additional parameters in the likelihood function (16). In the general case, we consider changing probabilities. Markov's assumptions of the first order determine that the probability of being in a certain regime depends on the previous state

$$P\left(r_t = j, r_{t-1} = i\right) = p_{ij}(t) \tag{17}$$

The probabilities $p_{ij}(t)$ can be a functions of some exogenous variables G_{t-1} and coefficients δ. For modelling the probabilities, we used the polynomial logistic specification. Since each row of the transition matrix determines the full set of conditional probabilities, we defined a separate specification for each i^{th} row

$$p_{ij}\left(G_{t-1}, \delta_i\right) = \exp\left((G_{t-1})' \delta_{ij}\right) \Big/ \left(\prod_{s=1}^{n} \exp\left((G_{t-1})' \delta_{is}\right)\right) \tag{18}$$

for $i, j = 1, \ldots, R$ and normalisation $\delta_{iR} = 0$. If switching is assumed with constant probabilities, G_{t-1} includes only constants.

Table 2 Statistical characteristics of UR for European countries

	2000–2017	*2000–2004*	*2005–2008m6*	*2008m7–2010m6*	*2010m7–2013m11*	*2013m12–2016m03*	*2016m04–2017m04*
Austria	0.007	0.024	–0.028	0.045	0.024	0.013	–0.070
Belgium	0.004	0.041	–0.033	0.065	0.026	–0.009	–0.131
France	0.013	0.048	–0.031	0.093	0.038	0.002	–0.045
Norway	0.002	0.026	–0.050	0.048	0.000	0.058	–0.043
Finland	–0.003	–0.020	–0.056	0.123	0.003	0.040	0.007
Slovakia	–0.042	–0.032	–0.191	0.323	0.010	–0.147	–0.151
Czech	–0.017	–0.028	–0.087	0.172	0.002	–0.097	–0.087
Hungary	0.013	–0.013	0.033	0.177	–0.030	–0.094	–0.104
Romania	–0.008	0.014	–0.045	0.084	0.002	–0.016	–0.073
Latvia	–0.003	–0.073	–0.141	0.625	–0.192	–0.064	–0.092
Lithuania	–0.018	–0.129	–0.158	0.573	–0.176	–0.138	–0.041
Estonia	–0.021	–0.117	–0.141	0.603	–0.194	–0.083	–0.144
Poland	–0.069	0.101	–0.274	0.155	0.028	–0.129	–0.154
Bulgaria	–0.038	–0.081	–0.136	0.240	0.066	–0.185	–0.136
Portugal	0.047	0.064	0.025	0.159	0.147	–0.119	–0.161
Slovenia	0.017	–0.001	–0.045	0.154	0.079	–0.063	–0.018
Croatia	0.003	–0.042	–0.112	0.154	0.155	–0.112	–0.179
Sweden	0.009	0.026	–0.037	0.136	–0.002	–0.044	–0.028
Italy	0.019	–0.044	–0.041	0.093	0.135	–0.051	–0.042
Netherlands	0.015	0.037	–0.047	0.082	0.076	–0.048	–0.120
Spain	0.082	–0.004	–0.044	0.363	0.195	–0.201	–0.204
Greece	0.096	–0.036	–0.063	0.215	0.431	–0.127	–0.051

Source: Data from EUROSTAT database, elaborations of the authors

4 Data

We conduct an empirical analysis and econometric modelling of UR behaviour for different European Union. Econometric modelling has been performed by using monthly data for 2000–2017 that were obtained from EUROSTAT. Before model construction, we seasonally adjusted all the series using Censusx12 method[1].

For all countries, we can identify periods in which the level of unemployment has shown some trends in the dynamics. Although these periods and their duration vary from country to country, it is possible to conduct some grouping of countries and periods. Table 2 shows the average changes in the seasonally adjusted UR of each country for different periods. The period 2008–2010 is characterised by rising unemployment and, consequently, positive changes in value for all countries. However, further periods reveal the diverse characteristics of each labour market. The visual analysis and statistical properties of the series show that in Austria, Belgium, France, Norway, and Finland the UR continued to increase since 2010, albeit slowly but still growing, and began to gradually decline only from the middle of 2016. In Slovakia, the Czech Republic, Hungary, Romania, the level of unemployment began to decrease since the end of 2013, remaining relatively unchanged during 2010–2013. In the Baltic countries, the UR has sharply increased from 2008 to 2010, but after these two unfavourable years, it has fallen fast for next three years (2010–2013) and continues to decrease. In Poland, Bulgaria, Portugal, Slovenia, Croatia, the increase in unemployment did not stop in 2010. In these countries, the UR continued to increase gradually until the end of 2013. Similar tendencies were also observed in Italy, Netherlands, Spain and Greece. However, the amplitudes of changes in these countries show the specific properties and market problems of these countries.

5 Econometric modelling and results

In order to identify different regimes of UR behaviour, we use the following specification

$$\Delta UR_t = \alpha(r_t) + \beta(r_t)\Delta UR_{t-1} + \gamma\Delta UR_{t-2} + \theta\Delta UR_{t-3} + \sigma(r_t)\varepsilon_t \quad \text{for } r_t = 1, 2, \tag{19}$$

where ΔUR_t are the first differences of seasonally adjusted time series of UR; $\varepsilon_t \sim N(0, \sigma^2)$. The model (19) is based on equation (10) and represent an autoregressive MS model with three lags (p = 3).The state variable r_t is assumed to follow a two-regime Markov process as described above.

In this model, the intercept and first lag coefficients depend on the regime of the UR behaviour. The autoregressive coefficients of the second and third lags are invariant from the regime. Model (19) also takes into account the possibility of residuals variance to be different for different modes.

We consider two states of UR behaviour, the changes occurs by two-regime Markov chain. In general, these regimes correspond with two economic activities phases and reflect two main state of business cycle. The dynamic of labour market as other economic variable is in relationship with economic downturns and expansions. However, the dynamic of UR due to hysteresis could show asymmetric properties of fluctuations and show inherent behaviour after recession. Hysteresis means that the dynamics of the process are not similar for the movement in opposite directions, that is, the curves describing changes in the positive and negative directions do not coincide. Negative temporary shock can have persistent long effect on natural level of unemployment. Especially, if recession phase is long and unemployment is high, then the natural UR may not return to the previous level, but approach some higher value. The reason of hysteresis is looseness of skills, motivation and change in preferences. Since unemployed workers do not gain experience and do not improve their work skills and abilities, their human resources may become worse or outdated. Therefore, for workers who lose their jobs because of falling the labour demand, job search is becoming more complicated, especially if the economic downturn was long and significant.

The transition probabilities can change and depend on variable ΔUR_EU28_{t-1} which describes the average change in European UR at previous period. In order to estimate these probabilities, we use the logistic specification

$$P_{ij}\left(\Delta UR\_EU28_{t-1},\delta\right)=\exp\left(\delta 1_{ij}\Delta UR+EU28_{t-1}\right)/\left(\exp\left(\delta 1_{i1}+\delta 2_{i1}\Delta UR+EU28_{t-1}\right)\right.$$
$$\left.+\exp\left(\delta 1_{i2}+\delta 2_{i2}\Delta UR+EU28_{t-1}\right)\right) \quad (20)$$
$$i,j=1,2,$$

For identification, we put $\delta 1_{i2} = 0$, $\delta 2_{i2} = 0$ ($i = 1, 2$), thus, the transition probabilities are obtained by the formulas

$$\begin{aligned} p_{11}(t) &= p_{11}\left(\Delta UR\_EU28_{t-1},\delta\right) \\ &= \exp\left(\delta 1_{11}\Delta UR\_EU28_{t-1}\right)/\left(1+\exp\left(\delta 1_{11}+\delta 2_{11}\Delta UR\_EU28_{t-1}\right)\right) \end{aligned} \quad (21)$$

$$p_{12}(t)=p_{12}\left(\Delta UR\_EU28_{t-1},\delta\right)=1/\left(1+\exp\left(\delta 1_{11}+\delta 2_{11}\Delta UR\_EU28_{t-1}\right)\right) \quad (22)$$

$$\begin{aligned} p_{21}(t) &= p_{21}\left(\Delta UR+EU28_{t-1},\delta\right) \\ &= \exp\left(\delta 1_{21}+\delta 2_{21}\Delta UR\_EU28_{t-1}\right)/\left(1+\exp\left(\delta 1_{21}+\delta 2_{21}\Delta UR\_EU28_{t-1}\right)\right) \end{aligned} \quad (23)$$

$$p_{22}(t)=p_{22}\left(\Delta UR\_EU28_{t-1},\delta\right)=1/\left(1+\exp\left(\delta 1_{21}+\delta 2_{21}\Delta UR\_EU28_{t-1}\right)\right) \quad (24)$$

The estimation was performed by maximum likelihood method. From the properties of Markov transition probabilities it follows that in order to get the maximum of likelihood function, represented by the right-hand side of (16), we should use recursive iterations. Each step of recursion begins with filtered regime probabilities for the previous period. Based on the probabilities $P(r_{t-1} = m \mid \Omega_{t-1})$, the recursion is divided into three steps. At first, we construct one-step ahead predictions of the regime probabilities based on Markov transition matrix

$$\begin{aligned} P\left(r_t=m\middle|\Omega_{t-1}\right) &= \sum\nolimits_{j=1}^{2} P\left(r_t=m\middle|r_{t-1}=j\right)\cdot P\left(r_{t-1}=j\middle|\Omega_{t-1}\right) \\ &= \sum\nolimits_{j=1}^{2} p_{jm}\left(\Delta UR\_EU28_{t-1},\delta_j\right)\cdot P\left(r_{t-1}=j\middle|\Omega_{t-1}\right) \end{aligned} \quad (25)$$

Next, we use these one-step ahead forecast probabilities to form the aggregate density of data and regimes at period t:

$$f\left(y_t,r_t=m\middle|\Omega_{t-1}\right)=1/\sigma_m\,\varphi\left(y_t-\mu_t(m)/\sigma(m)\right)\cdot P\left(r_t=m\middle|\Omega_{t-1}\right) \quad (26)$$

where $\mu_t(m) = \alpha(r_t) + \beta(r_t)\Delta \mathrm{UR}_{t-1} + \gamma\Delta UR_{t-2} + \theta\Delta UR_{t-3}$ .Each element of the likelihood function for period t is obtained by summing the aggregate probabilities across unobserved states getting marginal distribution of the observed data

$$L_t(\alpha, \beta, \gamma, \theta, \sigma, \delta) = f(y_t|\Omega_{t-1}) = \sum_{m=1}^{2} f(y_t, r_t = m|\Omega_{t-1}) \tag{27}$$

The last step is the filtering of probabilities using the results in the equation (26) in order to update the one-step ahead forecast probabilities:

$$P(r_t = m|\Omega_t) = f(y_t, r_t = m|\Omega_{t-1}) \Big/ \sum_{j=1}^{2} f(y_t, r_t = j|\Omega_{t-1}) \tag{28}$$

These actions are repeated successively for each period, $t = 1, \ldots, T$. We only required initial probabilities $P(r_0 = m|\ \Omega_0)$. The likelihood function that was obtained by summation of terms in equation (27) was investigated by maximum with respect to parameters (β, γ, σ, δ) using iterative methods. In our labour market research, for each presented estimation, the maximisation was performed using 40 different starting values.

Estimations of the model coefficients and error variances for each of the two regimes are given in Table 3. The standard errors and p-values, associated with each parameter, are presented in parentheses. Hence, Table 3 includes the estimates of the constants (α_r), the parameters by the first order lag (β_r) for each regime, the estimation of the invariant coefficients for the second and third lags (γ and θ) and the error variances for two regimes (σ_r^2). Additionally, Table 3 contains some average steady levels of change in the UR for each country that correspond to the two regimes ΔUR_1 and ΔUR_2 and are determined on the basis of the autoregression polynomial coefficients by the formula

$$\Delta UR_r = \alpha_r / (1 - \beta_r - \gamma - \theta), \quad r = 1, 2 \tag{29}$$

The evaluation results show that for each country, the model is able to separate the behaviour of the UR into two distinct regimes. The first regime for all countries is characterised by the negative average changes and decrease of unemployment so it corresponds to the improvement of the situation on the labour market (Table 3, column 10). By the second regime, the model describes either the dynamics of rising unemployment (for most countries) or its relative stability (Table 3, column 11).

The value of the Durbin-Watson statistics used for checking the residuals autocorrelation is given in the last column of Table 3. For all countries, the value of DW statistics is close enough to 2, which indicates the absence of model's residuals autocorrelation for each country.

We have found out that the regime-switching model has split the data into two distinct regimes, one with a low value of intercept and another with a higher mean (columns 2–3). The results of modelling indicate the significant differences in means for different regimes. For most countries, intercept of first regime is negative. Therefore, it characterises the phase of falling unemployment. The intercept of second regime is mostly positive. The second phase describes the growth of UR. However, for some new EU members (Bulgaria, Lithuania, Poland, Hungary), one regime corresponds to reducing unemployment, but the other regime to its relative stability.

Table 3 The estimation results of MS model for UR in EU countries

	α_1	α_2	β_1	β_2	γ	θ	$(\sigma_1)^2$	$(\sigma_2)^2$	ΔUR_1	ΔUR_2	DW
France	–0.003	0.013	0.369	0.481	0.068	0.015	0.114	0.039	–0.005	0.031	2.017
	(0.011)	(0.007)	(0.095)	(0.131)	(0.081)	(0.069)	(0.075)	(0.143)			
	[0.798]	[0.058]	[0.000]	[0.000]	[0.397]	[0.827]	[0.000]	[0.000]			
Belgium	–0.019	0.034	0.505	0.259	–0.018	–0.281	0.190	0.074	–0.023	0.033	1.838
	(0.018)	(0.010)	(0.084)	(0.117)	(0.072)	(0.069)	(0.078)	(0.092)			
	[0.309]	[0.001]	[0.000]	[0.027]	[0.802]	[0.000]	[0.000]	[0.000]			
Finland	–0.106	0.005	–1.392	–0.208	–0.142	0.111	0.483	0.255	–0.044	0.004	1.978
	(0.096)	(0.026)	(0.337)	(0.057)	(0.062)	(0.059)	(0.123)	(0.101)			
	[0.273]	[0.853]	[0.000]	[0.000]	[0.023]	[0.059]	[0.000]	[0.000]			
Norway	–0.002	0.020	0.145	–0.073	0.226	–0.125	0.113	0.003	–0.003	0.021	1.904
	(0.010)	(0.002)	(0.096)	(0.006)	(0.011)	(0.014)	(0.062)	(0.270)			
	[0.833]	[0.000]	[0.128]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]			
Czech	–0.027	–0.028	–0.124	–1.433	–0.143	0.470	0.238	0.082	–0.033	–0.013	2.075
	(0.019)	(0.062)	(0.075)	(0.112)	(0.069)	(0.065)	(0.058)	(0.769)			
	[0.163]	[0.647]	[0.100]	[0.000]	[0.038]	[0.000]	[0.000]	[0.001			
Italy	–0.049	0.209	–0.192	–0.753	–0.047	–0.013	0.225	0.571	–0.039	0.115	2.038
	(0.027)	(0.119)	(0.061)	(0.309)	(0.060)	(0.061)	(0.107)	(0.166)			
	[0.068]	[0.079]	[0.002]	[0.015]	[0.429]	[0.838]	[0.000]	[0.001]			
Romania	–0.039	0.014	–1.399	–0.050	0.106	0.134	0.324	0.172	0.018	0.017	1.948
	(0.065)	(0.018)	(0.268)	(0.061)	(0.058)	(0.072)	(0.140)	(0.083)			
	[0.545]	[0.443]	[0.000]	[0.419]	[0.066]	[0.063]	[0.000]	[0.000]			
Bulgaria	–0.016	–0.008	0.948	0.921	–0.148	–0.162	0.154	0.023	–0.043	–0.021	1.980
	(0.014)	(0.007)	(0.068)	(0.046)	(0.067)	(0.043)	(0.064)	(0.215)			
	[0.261]	[0.276]	[0.000]	[0.000]	[0.027]	[0.000]	[0.000]	[0.000]			
Slovakia	–0.035	–0.006	0.527	0.712	0.146	–0.049	0.088	0.221	–0.093	–0.032	1.904
	(0.019)	(0.031)	(0.102)	(0.122)	(0.083)	(0.063)	(0.129)	(0.142)			
	[0.071]	[0.844]	[0.000]	[0.000]	[0.079]	[0.436]	[0.000]	[0.000]			

Note: Standard error in (), *p*-value in [].

Source: Data from EUROSTAT database, elaborations of the authors

Table 3 The estimation results of MS model for UR in EU countries (continued)

	α_1	α_2	β_1	β_2	γ	θ	$(\sigma_1)^2$	$(\sigma_2)^2$	ΔUR_1	ΔUR_2	DW
Croatia	–0.024	0.020	0.408	0.263	0.244	0.044	0.099	0.265	–0.078	0.044	1.991
	(0.014)	(0.035)	(0.129)	(0.130)	(0.072)	(0.070)	(0.131)	(0.132)			
	[0.083]	[0.568]	[0.002]	[0.043]	[0.00]	[0.535]	[0.000]	[0.000]			
Poland	–0.041	–0.004	0.745	0.780	0.080	–0.081	0.207	0.097	–0.159	–0.020	1.974
	(0.035)	(0.010)	(0.137)	(0.078)	(0.096)	(0.072)	(0.151)	(0.091)			
	[0.248]	[0.657]	[0.000]	[0.000]	[0.402]	[0.263]	[0.000]	[0.000]			
Estonia	–0.110	0.892	0.248	0.231	0.023	–0.136	0.397	0.206	–0.127	1.011	1.973
	(0.035)	(0.126)	(0.077)	(0.165)	(0.072)	(0.072)	(0.061)	(0.302)			
	[0.002]	[0.000]	[0.001]	[0.161]	[0.751]	[0.059]	[0.000]	[0.000]			
Lithuania	–0.031	–0.021	0.661	0.199	0.227	–0.146	0.326	0.123	–0.118	–0.029	2.037
	(0.033)	(0.029)	(0.108)	(0.127)	(0.084)	(0.071)	(0.086)	(0.263)			
	[0.354]	[0.468]	[0.000]	[0.117]	[0.007]	[0.040]	[0.000]	[0.000]			
Latvia	–0.081	0.014	0.548	1.239	–0.195	–0.143	0.311	0.146	–0.103	0.141	2.082
	(0.042)	(0.018)	(0.104)	(0.082)	(0.094)	(0.082)	(0.106)	(0.122)			
	[0.051]	[0.439]	[0.000]	[0.000]	[0.039]	[0.079	[0.000]	[0.000]			
Hungary	–0.013	–0.003	0.282	0.483	0.121	–0.052	0.065	0.168	–0.020	–0.007	2.003
	(0.008)	(0.016)	(0.095)	(0.090)	(0.077)	(0.067)	(0.095)	(0.067)			
	[0.112]	[0.848]	[0.003]	[0.000]	[0.116]	[0.442]	[0.000]	[0.000]			
Spain	–0.013	0.039	0.443	0.541	0.318	0.048	0.096	0.205	–0.068	0.417	1.856
	(0.011)	(0.031)	(0.093)	(0.100)	(0.070)	(0.062)	(0.080)	(0.106)			
	[0.217]	[0.206]	[0.000]	[0.000]	[0.000]	[0.444]	[0.000]	[0.000]			
Portugal	–0.033	0.022	0.315	0.301	0.230	0.070	0.037	0.179	–0.086	0.056	2.098
	(0.007)	(0.015)	(0.046)	(0.079	(0.040)	(0.044)	(0.161)	(0.061)			
	[0.000]	[0.143]	[0.000]	[0.000]	[0.000]	[0.115]	[0.000]	[0.000]			
Slovenia	–0.031	0.120	0.531	0.616	0.114	–0.327	0.111	0.153	–0.046	0.202	2.118
	(0.010)	(0.041)	(0.071)	(0.202)	(0.077)	(0.064)	(0.065)	(0.157)			
	[0.003]	[0.004]	[0.000]	[0.002]	[0.137]	[0.000]	[0.000]	[0.000]			

Note: Standard error in (), *p*-value in [].

Source: Data from EUROSTAT database, elaborations of the authors

As it could be predicted from the unconditional distributions of unemployment, the results in the columns 2–3 and 8–9 show the large differences in the constants and errors variations for two regimes. The switches in the first AR term (columns 4–5) are less extreme; nevertheless, the estimates of the first autoregression coefficient distinguish significantly for two different regimes for all countries except Bulgaria, Poland, Estonia and Portugal.

For most countries, the first mode that describes the decline in unemployment is characterised by a larger error variation and shows more volatility, whereas the second regime corresponds to lower variation and shows greater homogeneity of change. At the same time, Italy, Croatia, Portugal, Spain have a more volatile UR in recession regime, indicating significant variations in unemployment and instability for deterioration periods of the labour market in those countries. Finland ($(\sigma_1)^2 = 0.48$), Latvia, Lithuania, Estonia and Romania ($(\sigma_1)^2 > 0.3$) are characterised by relatively high volatility of the first regime in comparison with other countries, indicating significant changes in the reduction of unemployment during periods of improvement of the economic situation in these countries. The volatility of the first regime in Poland and the Czech Republic ($(\sigma_1)^2 = 0.2$) is slightly lower than in previous countries, however, higher than in all other countries.

Table 4 The estimation results for parameters of logistic function (20) and transition probabilities

	$\delta1_{11}$	$\delta2_{11}$	$\delta1_{21}$	$\delta2_{21}$	p_{11}	sp_{12}	p_{21}	p_{22}
France	8.547	31.171	–1.480	–2.736	0.896	0.104	0.203	0.797
	(6.291)	(22.062)	(0.516)	(3.288)	(0.255)	(0.255)	(0.085)	(0.085)
	[0.174]	[0.158]	[0.004]	[0.405]				
Belgium	4.745	–10.236	–3.072	–3.687	0.954	0.046	0.056	0.944
	(1.364)	(4.606)	(0.845)	(3.957)	(0.133)	(0.133)	(0.036)	(0.036)
	[0.001]	[0.026]	[0.000]	[0.352]				
Finland	–1.945	–0.080	–0.749	–2.059	0.125	0.875	0.331	0.669
	(0.953)	(1.431)	(0.557)	(2.303)	(0.002)	(0.002)	(0.086)	(0.086)
	[0.041]	[0.955]	[0.179]	[0.371]				
Norway	2.684	–2.698	1.601	1.392	0.928	0.072	0.827	0.173
	(0.524)	(1.673)	(0.984)	(4.883)	(0.046)	(0.046)	(0.040)	(0.040)
	[0.000]	[0.107]	[0.104]	[0.776]				
Czech	2.706	4.331	2.047	3.121	0.917	0.083	0.869	0.131
	(1.016)	(3.327)	(1.611)	(5.868)	(0.061)	(0.061)	(0.066)	(0.066)
	[0.008]	[0.193]	[0.204]	[0.595]				
Italy	–1.496	0.817	–0.764	1.114	0.817	0.183	0.682	0.318
	(0.631)	(2.603)	(0.920)	(3.266)	(0.025)	(0.025)	(0.049)	(0.049)
	[0.018]	[0.754]	[0.406]	[0.733]				
Romania	1.198	0.333	1.363	4.092	0.232	0.768	0.235	0.765
	(0.689)	(2.457)	(0.548)	(2.924)	(0.012)	(0.012)	(0.129)	(0.129)
	[0.082]	[0.892]	[0.013]	[0.162]				

Note: Standard error in (), p-value in []

Source: data from EUROSTAT Database, elaborations of the authors.

Table 4 The estimation results for parameters of logistic function (20) and transition probabilities

	$\delta 1_{11}$	$\delta 2_{11}$	$\delta 1_{21}$	$\delta 2_{21}$	p_{11}	sp_{12}	p_{21}	p_{22}
Hungary	59.563	199.360	–6.013	–15.655	0.929	0.071	0.044	0.956
	(198.521)	(661.736)	(2.599)	(8.378)	(0.225)	(0.225)	(0.112)	(0.112)
	[0.764]	[0.763]	[0.021]	[0.062]				
Croatia	–1.862	0.164	1.478	–6.586	0.866	0.134	0.234	0.766
	(0.575)	(4.056)	(0.804)	(5.505)	(0.004)	(0.004)	(0.204)	(0.204)
	[0.001]	[0.968]	[0.066]	[0.232]				
Lithuania	–2.259	–4.204	1.156	–7.887	0.897	0.103	0.262	0.738
	(0.878)	(4.842)	(0.683)	(11.038)	(0.044)	(0.044)	(0.150)	(0.150)
	[0.010]	[0.385]	[0.090]	[0.475]				
Latvia	–1.989	–6.049	1.920	3.454	0.826	0.174	0.149	0.851
	(0.747)	(3.572)	(0.506)	(4.163)	(0.147)	(0.147)	(0.080)	(0.080)
	[0.008]	[0.090]	[0.000]	[0.407]				
Estonia	5.594	–28.338	–0.411	–0.097	0.945	0.055	0.399	0.601
	(1.523)	(11.553)	(0.735)	(2.981)	(0.171)	(0.171)	(0.003)	(0.003)
	[0.000]	[0.014]	[0.576]	[0.974]				
Bulgaria	–3.549	12.874	0.594	–29.983	0.939	0.061	0.415	0.585
	(0.868)	(5.435)	(1.151)	(32.441)	(0.115)	(0.115)	(0.372)	(0.372)
	[0.000]	[0.018]	[0.606]	[0.355]				
Slovakia	1.220	2.581	–0.366	–24.564	0.767	0.233	0.460	0.540
	(0.636)	(5.649)	(0.855)	(15.041	(0.050)	(0.050)	(0.337)	(0.337)
	[0.055]	[0.648]	[0.669]	[0.102]				
Poland	–2.024	–35.349	2.419	8.890	0.695	0.305	0.111	0.889
	(1.858)	(26.515)	(0.697)	(4.757)	(0.344)	(0.344)	(0.098)	(0.098)
	[0.276]	[0.183]	[0.001]	[0.062]				
Spain	–3.853	–23.919	1.268	22.289	0.758	0.242	0.418	0.582
	(2.073)	(15.127)	(1.208)	(12.937)	(0.346)	(0.346)	(0.404)	(0.404)
	[0.063]	[0.114]	[0.294]	[0.085]				
Portugal	1.108	21.557	–2.577	–15.468	0.642	0.358	0.142	0.858
	(0.775)	(15.803)	(0.585)	(5.376)	(0.300)	(0.300)	(0.176)	(0.176)
	[0.153]	[0.173]	[0.000]	[0.004]				
Slovenia	4.793	–71.385	1.964	–22.105	0.786	0.214	0.785	0.215
	(4.524)	(81.456)	(1.341)	(16.979)	(0.350)	(0.350)	(0.251)	(0.251)
	[0.289]	[0.381]	[0.143]	[0.193]				

Note: Standard error in (), p-value in []

Source: data from EUROSTAT Database, elaborations of the authors.

Table 4 present estimations of logistic function parameters that describe the transition probabilities from one state to another, as well as the estimated values of the transition matrix parameters together with their standard errors in parentheses. The point estimates of the expected mean of transition probabilities show different persistence of two regimes in different countries. The results show that there is a significant dependence of the probability of transition to some next regime on the regime, which the economy is at this moment in.

The estimation results for the parameters of function (21)–(24) are given in columns 2–5 of the Table 4. The standard errors and p-values, presented in brackets, show their significance. Note that the transition probabilities depend on the average change of the UR in European Union that occurred in the previous period. Namely, the probability of the transition between different regimes can respond to changes in the average EU UR. At the same time, for Belgium, Latvia and Estonia, the changes in the EU average influence the probability of falling unemployment (first regime), while for Portugal, Spain, Poland, Hungary, Slovakia we get the opposite results that show us that the second regime probabilities depend on the average changes in the EU. For the rest of the countries, the probability of transition does not respond to changes in the trends taking place in the EU.

The estimated probabilities of transition from a state to state are presented in columns 5–8. In particular, the mean of expected probability of staying in regime 1 given that UR was in regime 1 in the immediately preceding quarter is presented in column 5. The mean of expected probability of staying in regime 2 given that *UR* was in regime 2 previously, is presented in column 8 respectively. For most countries, the probability of remaining in the previous regime, regardless of whether the regime describes the decline or increase in unemployment, is higher than the probability of the exit from the current regime and, accordingly, the transition to the opposite regime. However, for a number of countries, we observe a significant attraction only to one regime. In particular, for Norway, the Czech Republic, Italy, Slovenia, the probability of transition to the first regime is greater than the probability of transition to the second state from any current regime. On the contrary, for Finland and Romania, the probability of transition to the second regime is greater.

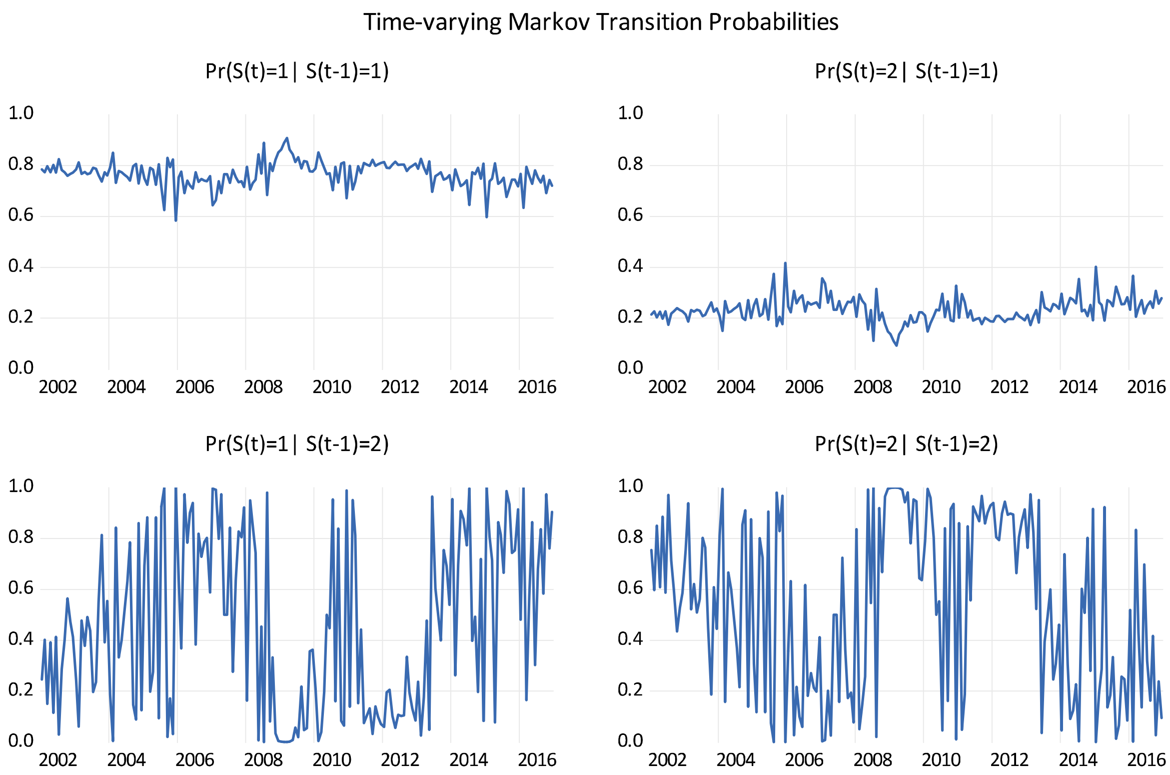
There is quite different persistence of staying in different states for different countries. For two countries (Belgium and France), we got very high values of both these probabilities. This indicates that both regimes are highly stable with very small chance of moving from a low *UR* to a high *UR* regime and vice versa for these countries. For France, we obtain two relatively stable own regimes, one for smooth (not significant) decline, second for moderate growth. The probabilities of transition from regime to regime do not depend on previous changes that occurred on average in the EU. At the same time, the probabilities of remaining in these regimes are 90% and 80% respectively, so the probability of transition from 2 to 1 regime is near 20%. For Belgium, both regimes are very stable. The probability of remaining in the previous state exceeds 90%, so the probability of transition to the opposite regime is very small. The first regime significantly dependent on the average European tendencies and it is counter-cyclical to them, however, the second regime is characterised by its own processes.

For Finland, regardless of the previous regime, higher probabilities have been got for leaving the second regime that describes the aggravation of labour market conditions. Besides it, both of regimes are not influenced by the average EU tendencies. In Hungary, Latvia and Lithuania both regime are stable that we can consider as some steady states of unemployment.

Some European countries have only one stable regime. Particularly, the labour markets of Norway, the Czech Republic, Italy, Estonia, Bulgaria, Slovenia, Spain and Slovakia are characterised by first stable regime with decline of unemployment. For Romania, Poland and Portugal, the second regime that corresponds to increase of unemployment is more stable.

In addition to these results, we should emphasise that in our model the specification that determine the transition probabilities includes the variable which characterises the average European trend of the unemployment dynamics. Since in different periods this trend varied, according to our model, the probability of transition between regimes in different periods was different. In particular, for Slovakia, we observe the stability of transition probabilities for first regime, and the significant differences between the probabilities for being in the second regime in different periods (Figure 2). At the same time, we may also notice a slight negative trend in the probabilities of staying in the first regime that can reveal some mitigation of regime that corresponds to unemployment decline, as well as some increase the probability of transition from the first to the second regime. The second regime remained relatively stable during 2009 and 2012, while in other periods the probability of its exiting was very fluctuating.

Figure 2 The time-varying probabilities of transition from one regime to another during 2002–2016 for Slovakia (see online version for colours)

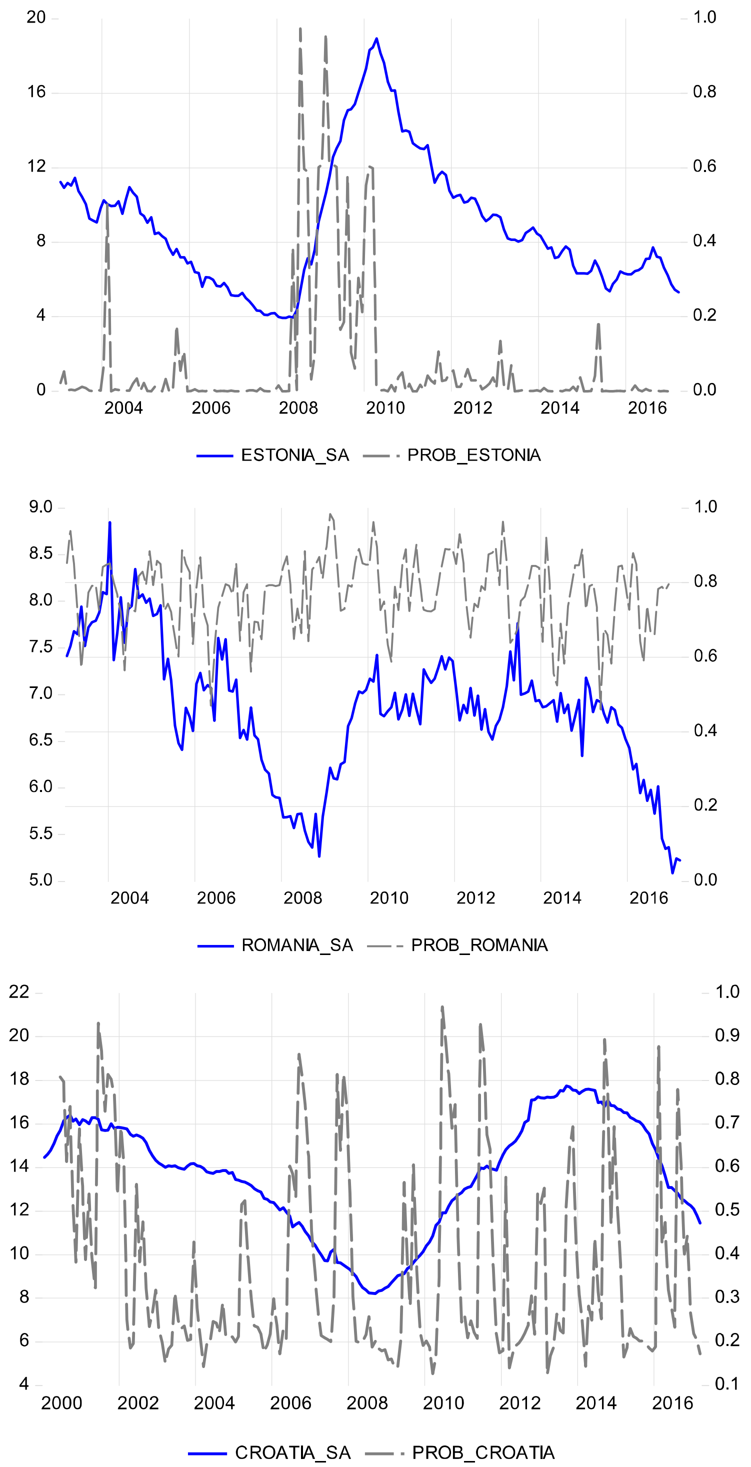


Source: Authors' evaluations

The constructed model gives us also a possibility to predict the probability of staying in some state at each period. Figure 3 depicts UR forecast for some countries. The left vertical axis reflects the values of UR, the right vertical scale corresponds to the forecasted probability of falling into the second regime with unfavourable rising unemployment trends for some countries. Each country shows its own peculiarities.

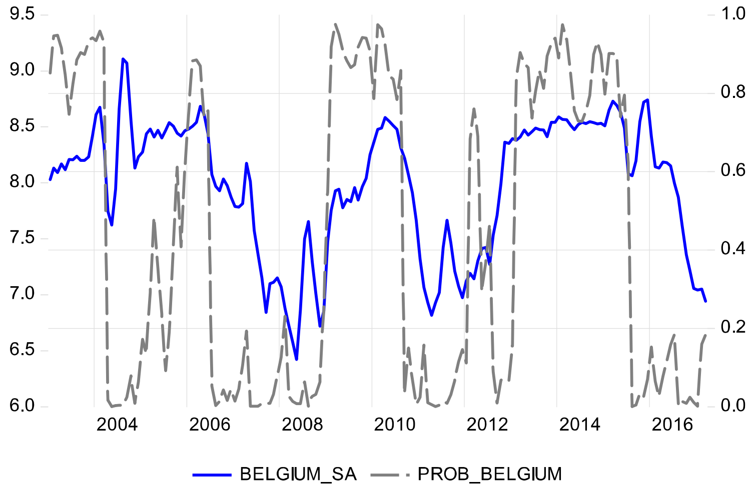
Probability to go into disadvantaged situation is estimated as high in all periods for Romania. For Estonia, it was high only during 2008–2010, for Belgium – in 2003, 2009, 2013–2015. Unlike previous countries, for Croatia, the probability of being in some of the different regimes is often changing,

Figure 3 The dynamics of UR and the forecasted probabilities to be in second regime of unemployment rising for Estonia, Belgium, Croatia and Romania (see online version for colours)



Source: Authors' evaluations

Figure 3 The dynamics of UR and the forecasted probabilities to be in second regime of unemployment rising for Estonia, Belgium, Croatia and Romania (continued) (see online version for colours)



Source: Authors' evaluations.

6 Conclusions

The dynamics of European unemployment showed considerable fluctuations and asymmetric behaviour during business cycle over the past decade. The dynamic pattern of UR demonstrated the significant differences for different countries that very distinguished during its growth and decline periods. Despite the fact that strong negative perturbations of the economic environment, which occurred at the end of 2008, have led to an increase in unemployment in all the EU countries, the response effects to these disturbances had different amplitudes and duration of the unemployment fluctuations for different countries, showing the peculiarities of individual labour markets.

To describe the differences in dynamic properties of UR in different economic situation, we used the MS autoregressive models with time-varying probabilities of transition between different regimes of behaviour. The results revealed that the UR in all European countries behaved asymmetrically over the business cycle so we got different processes for describing of unemployment dynamics in each phase of the economy. The developed models for each country allowed capturing the asymmetry by supposing the parameters of an autoregressive model to depend on a stochastic state variable that was hidden and corresponded to business cycle phases in the interpretation.

The evaluation results proved that for each country we should separate the behaviour of UR into two distinct regimes. The first regime for all countries reflected the negative average changes and declining trend of unemployment so it corresponds to the improvement of the situation on the labour market. By the second regime, the model described either the dynamics of rising unemployment for most countries or its relative stability. For most countries, the first mode, described the decline in unemployment, was characterised by a larger error variation and showed more volatility, whereas the second regime corresponded to lower variation and showed greater homogeneity of change.

The transition probabilities that we estimated by means of logistic function revealed different persistence of two regimes in different countries. For some countries, we obtained that two regimes had stable properties; however, for other countries, there was only one stable regime. The duration of being in each regime was also very different for different countries. The results also showed that for some countries the probability of UR regime changes significantly depended on the average change of the UR in European Union that occurred in the previous period. However, for some countries it had influence on first regime whereas for other countries it had influence the second regime.

Created model makes it possible to increase the adequacy of modelling and forecasting of future trends on the labour markets corresponding to particularities of asymmetric dynamic properties for different state of economic environment in each country.

In the process of policy design is necessary to take into consideration the differences in speed of UR change, its persistence and duration for different development state as well as the peculiarities of labour market processes that are inherent for each European country. During expansion when unemployment is low, relatively stable or even slowly declines, the economic policy can be more prudent. However, during the recession when unemployment undergoes abrupt change and we observe sharp increase in UR, the economic policy needs to be more manoeuvring. Each country should improve its policy in this unfavourable period to prevent unfavourable dynamics of UR and to be able to respond to great effect of negative shocks. The magnitude of policy reaction should differ for different countries taking into account speed of possible increase in unemployment for specific country, the probability of future remaining in regime with increasing unemployment and duration of recovery period.

Policy design should take into account that unemployment peak occur in some time after business cycle troughs and the following period of high UR can be much longer as duration of business cycle downturn that is crucial for recovery in general. Recognising of switching in UR to unfavourable regime and creating protecting policy, due to shrink hazard rate of escaping employment, is important especially for the country where the probability of such switching is high. For countries that show high probability to stay in regime with high UR after recession and are characterised by slow unemployment declining processes, it is important to include in policy decision the incentives to extend the hazard rate of escaping unemployment in order to reach recovery faster.

Further integration and globalisation can be a reason of some eliminates the differences between labour markets and UR in different European countries. Migration stimulated by significant differences in URs during business cycle and different duration of labour markets recovery after recession across EU countries could lead to smoothing in demographic situation, social norms and preferences of participation in labour market, percent of participation of women, pay equivalence, improvement international cohesion and competitiveness. This process could create some policy unification concerning labour market regulation in EU countries but at the same time could create new challenges for particular labour markets in specific countries.

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Notes

1 The authors are willing to share the data used in empirical modelling with those who wish to replicate the results of this study.