HYSTERESIS AND THE NAIRU: THE CASE OF COUNTRIES IN TRANSITION

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Abstract:
The paper examines the hysteresis hypothesis in unemployment in the case of eight selected countries in transition, using the Kalman filter and testing whether the NAIRU time series are stationary. The empirical results show that the hysteresis effect is confirmed for the majority of the countries. Testing the influence of the inflation growth rate on the decline in the NAIRU and *vice versa*, performed using the panel regression with fixed effect, confirmed that the increase in inflation leads to decline in the NAIRU. The conclusion also suggests the existence of the impact of actual unemployment rate on the NAIRU, which may be affected by the change in aggregate demand.

Keywords: hysteresis, NAIRU, Kalman filter, inflation, unemployment.
JEL Classification: E24, E30, E50, C13

1. Introduction

Unemployment is a major problem, both in developed market economies, and countries that have gone through the transitional changes. Therefore, the goal of economic policy in modern economies is to reduce unemployment and thereby to avoid the rising inflationary pressures. In achieving this goal, the concept of Non - Accelerating Inflation Rate of Unemployment (NAIRU) and policy recommendations arising from this concept are of great importance.

NAIRU concept was first introduced by Modigliani and Papademos in 1975 (Snowdon, Vane, 2005, p. 402). Among economists, there are significant discrepancies in the definitions of the concepts of natural rate of unemployment (NRU), which was founded by Nobel Laureate M. Friedman, and the NAIRU. One group of scholars considers them identical (Gordon, Blanchard), while others argue that these are different concepts (Tobin, Stiglitz). The significant difference between the NRU and NAIRU relates to their different microeconomic basis. NRU concept implies market clearing, while the NAIRU refers to imperfect competition in labour and product markets. NAIRU is the unemployment rate with which the inflationary processes in excess demand markets are balanced with the disinflationary processes in excess supply markets. NAIRU can be defined under the different inflation rates, and at different rates of unemployment, and it responds to those conditions in the economy which allow stable rate of inflation. In contrast to the NRU, which implies that all markets are in equilibrium, NAIRU points out that not all markets have to be in balance.

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In addition to the discrepancies in the definition of the concept of NAIRU, in modern macroeconomic theory, there is considerable disagreement and controversy about the factors that determine the level and change of the NAIRU. One can distinguish two approaches to the factors that determine the NAIRU: exogenous and endogenous ones.

According to the exogenous approach, labour market characteristics, such as the bargaining power of trade unions, institutional arrangements, unemployment benefits, legislation, insider-outsider structures, *etc.* affect the NAIRU and increase the rigidity of the labour market. This approach emphasizes that the NAIRU is a result of these factors, which influence the wage increase and which in recent decades are often cited as the cause of rising unemployment in European countries. The exogenous approach finds the solution to this problem in labour market deregulation and unemployment benefits reduction (Sørensen & Whitta-Jacobsen, 2010, p. 341).

According to the endogenous approach, the NAIRU is determined by the level of the actual unemployment rate, which is the basis of hysteresis theory (Blanchard and Summers, 1988). The hysteresis theory argues that the NAIRU is growing in the current period if in the previous period the actual unemployment rate was higher than the NAIRU, which can be represented as follows (Snowdon, Vane, 2005, p. 405):

$$U_{Nt} = UNt_{-1} + \alpha\,(U_{t-1} - U_{Nt-1}) + b_t\ ,$$

Where U_{Nt} – NAIRU in t period,
U_{Nt-1} – NAIRU from the previous period,
U_{t-1} – actual unemployment rate from the previous period,
b_t – other variables which can influence the NAIRU (*e.g.* unemployment benefits).

If we assume that $b_t = 0$, we get the following equation:

$$U_{Nt} - U_{Nt-1} = \alpha\,(U_{t-1} - U_{Nt-1}).$$

We can see from this equation that $U_{Nt} > U_{Nt-1}$ if $Ut_{-1} > U_{Nt-1}$. In other words, changing the actual unemployment rate acts as a magnet that «draws» the NAIRU in the same direction. The argument that aggregate demand does not affect the NAIRU can be acceptable in the short run but in the long run higher or lower economic activity leads to the changes in the NAIRU. Endogenous approach attaches more importance to economic policy whose effect on the reduction in the actual unemployment rate can result in decrease in the NAIRU.

In addition to the relationship between the NAIRU and the actual unemployment rate, the relationship between the movements of the NAIRU rate and changes in the inflation rate, which is represented by the Phillips curve, should be mentioned. The variant of expectations-augmented Phillips curve, which includes the concept of NAIRU, is based on the assumption that the inflation rate will be constant when the actual unemployment rate is equal to the NAIRU; it will increase when the actual unemployment falls below the NAIRU, and *vice versa*. In general terms, it can be represented as follows (Bozani, Drydakis, 2011, pp. 15–16):

$$\pi_t = \pi_t^e + \beta\left(U_{t-1} - U_{Nt}\right) + \delta z_t + \varepsilon_t \qquad \beta < 0$$

where π_t is the actual rate of inflation in period t; π_t^e - the expected rate of inflation for period t, expected to be equal to the rate of inflation in period t-1; U_{t-1} - unemployment rate in period t-1; U_{Nt} - NAIRU in period t, which may be constant but may change with structural changes in the economy; z_t - a variable that refers to the supply shocks with *ex-ante* expected value of zero, and ε_t - a variable that reflects the influence of all other factors. If π_t^e is switched on the left side of the equation, we get:

$$\Delta\pi_t = \beta\left(U_{t-1} - U_{Nt}\right) + \delta z_t + \varepsilon_t \qquad \beta < 0$$

where $\Delta\pi_t$ is the difference between the rates of inflation in period t and t-1. If the unemployment rate exhibits hysteresis effect, the impact of the inflation rate on the NAIRU can be observed through the changes in the real rate of unemployment (for example, monetary expansion increases inflation and reduces unemployment, which is pulling down the NAIRU rate).

Given the large number of factors that determine the NAIRU, this paper will explore the impact of the actual unemployment rate on the NAIRU, or hysteresis effect, as well as the effect of inflation rate on the NAIRU on the example of selected countries in transition. The paper starts with the following basic research hypotheses:

H1: actual unemployment rate affects the NAIRU-there is hysteresis effect

H2: the increase in the inflation rate affects the decrease in the NAIRU and *vice versa*.

2. Literature Review

Monitoring of the hysteresis effect is the subject of many works. De-Chih Liu (2011) investigated the influence of hysteresis hypothesis on the opening and closing of job positions in the United States. The paper emphasizes the importance of demand management policy, where the fiscal and monetary policies stimulate aggregate demand, which in the short run has a positive impact on the opening of new job positions. However, the results of the research, using unit root tests based on the panel, show that the process of the opening and closing of job positions in the USA according to the structuralist paradigm (exogenous approach to determining the NAIRU), that the stabilization policy does not have a permanent effect on the opening and closing of job positions, and that the hysteresis hypothesis can be rejected.

Testing of the hysteresis hypothesis on the example of 14 OECD countries was performed by Liew, Chia, and Puah (2009), using several panel unit root tests. The results of the research show that hysteresis can be confirmed for most OECD countries, when tests are performed on individual countries. However, the hysteresis hypothesis in unemployment can be rejected for OECD countries overall, because unemployment rates tend to restore to long-run balance. This suggests that labour market institutions and stabilization policy successfully determine the unemployment rate at a sustainable level.

The research performed by Mohan, Kemegue, and Sjuib (2008) shows that the majority of studies, which were using the conventional unit root tests, supports the hysteresis hypothesis in OECD countries, and rejects the same hypothesis when investigating the labour market in the United States. This research, using the ADF Fisher, IPS, LLC, and Breitung panel unit root tests for individual regions in the United States, rejected the hysteresis hypothesis in unemployment.

Stockhammer and Sturn (2008) investigate the hypothesis that the extent to which hysteresis occurs in the aftermath of recessions depends on monetary policy reactions in 19 OECD countries. The results suggest strong effects of monetary policy, but weak effects of labour market institutions. Those countries which more aggressively reduced their real interest rates in the vulnerable period of a recession experienced a much smaller increase in the NAIRU.

The presence of hysteresis in the euro area was examined by Loageay and Tober (2005) using the Kalman filter. The results of this research confirmed the presence of hysteresis effect, particularly in Germany. León-Ledesma (2002) analysed the presence of hysteresis in unemployment in the United States and the European Union. The results show that the hysteresis is confirmed in European countries and rejected in the United States.

Ball (2009) analysed unemployment rates in 20 developed countries, using the HP filter, and came to the conclusion that there is hysteresis effect and that monetary policies can affect unemployment.

Although the hysteresis effect is mostly analysed in developed economies, there is an increasing number of researches in the European transition countries. León-Ledesma and McAdam (2003) investigated the presence of hysteresis in 12 transition countries of Central and Eastern Europe, using the unit root tests on individual time series and on panel data, as well as Markov switching model. The analysis also included the impact of structural breaks on the formation of multiple equilibrium states, which occur as a result of shocks. They compared these results with the results of the aggregate data analysis for 15 European countries (EU-15), and came to the conclusion that maintaining equilibrium is faster in transition countries, but the transitions from one equilibrium state to another are more frequent than in the EU-15.

Camamero, Carrion-i-Silvestre, and Tamarit (2005) test for the hysteresis *versus* the natural rate hypothesis on the unemployment rates of the EU new members. They found that the application of the standard GLS-class of unit root tests confirms the hysteresis in the unemployment rates, but the opposite is true when allowing for the presence of up to two structural breaks in unit root testing.

Cuestas and Ordonez (2011) show that for five CEE countries (Hungary, Latvia, Poland and Slovenia, and the Slovak Republic) unemployment dynamics appears to be well described as a stationary process around highly persistent structural changes.

Cuestas, Gil-Alana, and Staehr (2011) analyzed the dynamics of the unemployment rate in the eight CEE countries which joined the EU in 2004. They found that the unemployment rate is not stationary in most of the sample countries and that shocks are highly persistent, implying a slow rate of convergence to the natural rate of unemployment. The unemployment rate is least persistent in Hungary and Slovenia, more persistent in the Czech Republic, Slovakia and the Baltic States and extremely persistent in Poland.

Gozgor (2013) tested the hysteresis effect in ten CEE countries, and provide significant empirical support for the existence of persistence in unemployment rates, and the hysteresis hypothesis.

3. Model

In order to test the hypothesis defined in the introduction, two things have to be done. First, we need to determine the NAIRU from the actual unemployment data series, and second, we have to test the relation between NAIRU and inflation rate. Following previous considerations, the rate of unemployment can be viewed as the sum of three components: frictional, structural, and cyclical unemployment, where the first two components are parts of the NAIRU:

$$U_t = U_{Nt} + U_{cyc\ t} \quad (1)$$

where U_t is the observed actual unemployment rate in time t, U_N is the NAIRU, and U_{cyc} is the rate of cyclical unemployment.

In order to specify the empirical model which will detect the unobserved components (U_N and U_{cyc}) from the easily accessible actual rate of unemployment, the assumptions have to be made regarding the nature of the movement of the components U_N and $U^c{}_{yc}$.

Following the seminal work of Blanchard and Quah (1989), the fluctuations in unemployment (as well as in output) result from two types of shocks, supply shocks and demand shocks. Supply shocks (as changes in technology, demographic changes, *etc.*) alter the position of long-run aggregate supply curve, and change the level of full employment and potential output. On the other hand, the demand shocks (as changes in monetary and fiscal policy, changes in consumption, both foreign and domestic, *etc.*) do not influence the long run full-employment level of output. Thus, the main distinctions between these two types of disturbances are made regarding the lasting of their effects. While the supply shocks have permanent, long-lasting effects, the demand shocks have temporary influence on full-employment level of output.

Based on these considerations, widely accepted in the literature, it can be assumed that the NAIRU follows a random walk (see Gordon, 1997 and 1998; Laubach, 2001; Apel and Jansson, 1999a, 1999b; Claar, 2005):

$$U_{N\,t} = U_{N\ t\text{-}1} + \varepsilon_t \quad (2),$$

where ε_t is independently distributed error term with

$$\varepsilon_t \sim N(0, \sigma_\varepsilon^{\ 2}) \quad (3).$$

When the standard deviation $\sigma_\varepsilon = 0$, then U^N is constant over time. When $\sigma_\varepsilon \neq 0$, the model allows the NAIRU to vary by an amount σ_ε in each period.

Regarding the fluctuation in other component of actual rate of unemployment, the cyclical unemployment U^{cyc}, following Apel and Jansson (1999a, 1999b), and Claar (2005), we assume that it exhibits *first-order serial correlation*:

$$U_{cyct} = \rho U_{cyct\text{-}1} + \varepsilon'_t \quad (4),$$

where ρ is between zero and one, and where ε'_t is independently distributed error term with

$$\varepsilon'_t \sim N(0, \sigma_{\varepsilon'}^{\ 2}) \quad (5).$$

Presented model, with the use of two independently distributed shocks, one for NAIRU and the other for cyclical rate of unemployment, clearly distinguishes two types of shocks, supply shocks, which alter the NAIRU, and demand shocks which cannot alter the NAIRU. Detailed specification of the Kalman filter model is presented in the following section of the paper.

The second part of the model consists of the statistical test of relation between the NAIRU and inflation rate. We have employed the panel data regression model in this paper. A panel has the form X_{it}, where X is a vector of observed variables (NAIRU and inflation rate), i goes from 1 to N, where N is the number of observed countries, and t covers the period from 2000 to 2012.

A fixed effect panel data regression model can be written as:

$$U_{Nit} = \alpha + \beta \, CPI_{it} + u_{it} \quad (6),$$

$$U_{it} = \mu_i + \nu_{it} \quad (7),$$

Where U_N is the NAIRU, CPI is the consumer price index and μ_i is individual-specific, time-invariant effect.

The series of data used in this study is the quarterly unemployment rate and inflation rate of eight European transitional economies, ranging from 2000 to 2012. The countries' sample consists of five Central European economies (Poland, Hungary, the Czech Republic, Slovakia, Slovenia, all member states of the EU since 2004), and two East European economies (Bulgaria and Romania, members of the EU since 2007), and Croatia (a member of the EU since 2013). Data are taken from Eurostat.

4. Kalman Filter Method

Once the model is specified, the appropriate research method should be employed. Various methods were used in the literature for estimating the natural rate of unemployment (as well as the NAIRU), ranging from simple fitting the trend in the time series of unemployment to using structural models of labour market. Apel and Jansson (1999a) surveyed the common ones: Hodrick-Prescott filter, the so-called multivariate filter of Laxton and Tetlow, methods based on structural vector autoregressive models, and the so called STM (Structural Time-Series Models) or UC (Unobserved Components) models, and concluded that the last mentioned method has some significant advantages over others. Therefore, we employ the UC method in this paper, specifically the Kalman filter algorithm. The intuition behind this method is as follows: specified model relates the unobservable variable (NAIRU in this case) to observable variable - actual unemployment. A recursive Kalman-filter algorithm can be applied to the so called state-space representation of the model, in order to find a sequence of optimal predictions of the observable variable for a given set of coefficients and sequence of the unobservable one (Apel and Jansson, 1999a). By comparing these predictions to the actual values of unemployment, a specific series of forecast errors are used in a maximum likelihood routine to find the optimal set of parameters and the corresponding estimates of the natural rate of employment.

In order to apply the Kalman filter procedure, the system must be written in a state space form, with a measurement equation and a transition equation:

$Z_t = H X_t + \eta_t$ (measurement equation)

$X_t = A X_{t-1} + B U_t + \omega_t$ (transition equation)

where Z is a vector of observed variables, X is a vector of unobserved variables, and U is a vector of controlled variables. Matrixes H, A, and B contain parameters that correspond to X_t, X_{t-1}, and U_t, respectively. Terms η_t and ω_t are independently distributed error terms.

Our model, developed in the previous section, can be written in the state space form as follows. The equation (1) may be equivalently expressed as:

$$U_t = H X_t, \ t = 1, ..., T \tag{8}$$

where Xt is the 2x1 vector of the unobserved variables U^N and U^{cyc}. H is a fixed 1x2 vector that, in this model, contains ones for its elements. This is the *measurement equation* that relates the unobserved variables to the observable variable Ut.

Equations (2)-(5) can be written as *transition equations* as follows:

$$X_t = A X_{t-1} + \omega_t, \tag{9}$$

where A is a matrix with 1 and ρ on the main diagonal, and $\omega_t = (\varepsilon_{t,} \varepsilon'_t)$.

Following Claar (2005), our model does not contain error term η_t in the measurement equation. Claar (2005) justifies this by the fact that "the unemployment rate is measured reasonably well and, more importantly, it is measured in the same manner every period. Secondly, adding an additional term to the unemployment rate equation would exacerbate the problem of distilling the natural rate of unemployment (the NAIRU in this case) from the single unemployment rate series by introducing a third source of fluctuation in the unemployment rate". The model also does not contain matrix of controlled variables U_t in the transition equation, which is a common feature of models in relevant studies.

Before running the Kalman filter, the unknown parameters in the state space model (ρ, σ_ε^2, $\sigma_{\varepsilon'}^2$) should be estimated. The values of the variance of the error terms are estimated in the maximum likelihood process, while we have used a variety of starting values for ρ that are consistent with a business cycle half-life ranging from 6 to 48 months, which is a duration of temporarily disturbances to unemployment determined in Blanchard and Quah (1989), as well as in many other studies.

Another issue is to estimate the initial values of unobserved variables, which is necessary when the time series are non-stationary, as it is the case when the NAIRU is assumed to evolve as a random walk, like in our model. There are two traditional approaches to this problem. In the first one, the initial value of the NAIRU is considered to be fixed, while in the second approach, the initial value is presumed to be random, and a diffuse prior for the distribution is assumed. The second approach is used in this paper. More about the Kalman filter procedures and estimation techniques can be found in Claar (2005) and Turner, *et al.* (2001).

5. Results

Using the Kalman filter, the actual unemployment rates in the observed countries are decomposed into the NAIRU and cyclical component. The obtained NAIRU is shown in the Appendix. In the first quarter of 2000 (first observed quarter), Hungary had the lowest NAIRU (5.14), followed by Slovenia (6.47), Romania (7.01), and the Czech Republic (8.48). In contrast to this group of countries, there is a group of countries with high NAIRU in the first observed quarter, consisting of Bulgaria (18.46), Poland (19.78), and Slovakia (20.06). As a result of the successful transition reform and accession to the EU, there was a significant decrease in the NAIRU in all surveyed countries (except for Hungary) by the end of the period (2012Q4). In the last quarter of 2012, the Czech Republic had the lowest NAIRU (6.53), followed by Romania (6.97), Poland (7.72), Slovenia (8.10), and Bulgaria (9.69). The three countries which at the end of the period had the NAIRU over 10% are: Croatia (13.10), Slovakia (12.56), and Hungary (11.55). Higher NAIRU in the last compared to the first quarter (2012Q4 in contrast to 2000Q1) was observed only in the case of Hungary, while all other countries had a decline in the NAIRU in the observed period.

Bearing in mind that the hysteresis effect involves a change in the NAIRU over time, the existence of hysteresis can be tested by examining the existence of statistically significant deterministic or stochastic trend in the obtained series of the NAIRU. The results of testing the existence of the trend are presented in Table 1. There is statistically significant trend in six countries, of which in five cases there is a negative one (Bulgaria, Poland, Romania, Slovakia, and the Czech Republic), while in the case of Hungary there is a positive trend, *i.e.* the growth in NAIRU during the period (2000–2012). The trend is not statistically significant in the case of Slovenia and Croatia; their NAIRU does not show a tendency towards statistical significance over the time.

Table 1 | Analysis of the NAIRU trend

	Trend coefficient	R-squared
Bulgaria	-0.1838***	0.8229
Hungary	0.1287***	0.9816
Poland	-0.2579***	0.9938
Romania	-0.0012**	0.8837
Slovenia	0.0267	0.4779
Slovakia	-0.1577***	0.9391
Croatia	-0.0287	0.2010
Czech Republic	-0.0416***	0.8964

Source: own calculation

The existence of a hysteresis effect can alternatively be proved by testing whether the NAIRU time series are stationary. As stated in the section model, the assumption is that the NAIRU has a random walk, *i.e.* it is non-stationary series. Table 2 presents the results of Kwiatowski-Phillips-Schmidt-Shin (KPSS) test of whether the NAIRU time series are stationary. In all eight cases, one can reject the hypothesis on whether the NAIRU time series are stationary, *i.e.* conducted KPSS test confirms the existence of hysteresis effect on a sample of observed transition countries.

Table 2 | The Results of the KPSS Test on whether the NAIRU Is Stationary

	KPSS test statistics*
Bulgaria	0.2522***
Hungary	0.2519***
Poland	0.1302*
Romania	0.1528**
Slovenia	0.2503***
Slovakia	0.2461***
Croatia	0.2225***
Czech Republic	0.2462***

Source: own calculation

*Bandwidth: 5 (Newey-West automatic) using Bartlett kernel
note: *** - 0.01 **-0.05 *-0.1

The result of testing the hysteresis effect existence is consistent with previous studies carried out by Liew, Chia and Puah (2009) which confirmed the existence of this phenomenon in the case of OECD countries individually. It is also consistent with the studies that have confirmed the presence of hysteresis in developed countries, carried out by Loageay and Tober (2005), then Ball (2009), and León-Ledesma (2002).

Testing other research hypothesis - the hypothesis that an increase in the inflation rate affects the decline in the NAIRU and *vice versa* was performed using the method of panel regressions with fixed effects. Stationarity of the time series is provided using the Trend Stationary Process (TSP), in order to eliminate the deterministic trend, and using the Difference-Stationary Process (DSP), to eliminate the stochastic trend. Since the regression model on the first differences showed the existence of autocorrelation, *i.e.* statistical errors were positively correlated with statistical errors from previous periods (low value of the Durbin-Watson statistic), the first-order auto-regression model is defined (first order AR - AR (1)). The dependent variable was the first difference of the previously estimated NAIRU, while the first difference of consumer price index (CPI) is an independent variable of the regression equation. Panel regression results are presented in Table 3.

Table 3 | Panel Regression Results of the NAIRU Dependency on CPI

Total panel observations: 10x52=512				
Variable	**Coefficient**	**Std. Error**	**t-Statistic**	**Prob.**
C	10.15348	0.131172	77.40558	0.0000
D(CPI)	-0.003512	0.021700	-2.926778	0.0036
R-squared	0.765385			
Adjusted R-squared	0.733581			
F-statistic	24.06612			
Prob (F-statistic)	0.000000	DW stat.	1.676803	

Source: own calculation

The resulting regression equation confirms that inflation rate has a statistically significant effect on the NAIRU in the group of observed countries, *i.e.* monetary policy manifests effects on the NAIRU movement in a way that the increase in the inflation rate leads to the decrease in the NAIRU.

6. Conclusion

Because of the great importance, a number of theoretical and empirical literatures have evolved concerning hysteresis theory and the concept of the NAIRU. Hysteresis influences that unemployment dynamics is a non-stationary process, *i.e.* there is no unique level unemployment seeks in the long run. The paper tests the existence of hysteresis effect and the influence of inflation trends on the NAIRU on the example of eight countries in transition.

The NAIRU is determined using the Kalman filter, and the results of testing whether its series are stationary demonstrate that in the case of all the eight countries there is hysteresis effect. A similar result was obtained by testing the existence of a trend in the series of NAIRU when hysteresis was confirmed in the case of six countries of which in five cases there was decrease in the NAIRU over time (in the case of Bulgaria, Poland, Romania, Slovakia, and the Czech Republic), and increase in the case of Hungary in the period between 2000 and 2012. The trend is not statistically significant in the case of Slovenia and Croatia; their NAIRU does not show a tendency towards statistical significance over time.

Analysis of the impact of inflationary tendencies on the NAIRU was conducted using the panel regression analysis, and the results confirm the existence of a small but statistically significant effect of change in the consumer price index on the NAIRU. This means that the policy of demand management, *i.e.* monetary policy, can affect the movement of unemployment and inflation. Limitation of the model is that the results were obtained by testing only the impact of inflation on the NAIRU, without taking into consideration a number of factors concerning both demand and supply.

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Appendix

NAIRU for selected economies

	Bulgaria	Hungary	Poland	Romania	Slovenia	Slovakia	Croatia	Czech Republic
2000Q1	18.46833	5.14109	19.78095	7.015875	6.479235	20.06829		8.486852
2000Q2	18.12117	5.211158	19.61956	7.01588	6.451056	19.85564		8.420142
2000Q3	17.77375	5.281327	19.45788	7.015881	6.422899	19.64288		8.353474
2000Q4	17.42566	5.351781	19.29539	7.015872	6.394839	19.42988		8.28692
2001Q1	17.07644	5.422761	19.13132	7.015844	6.366976	19.21643		8.220556
2001Q2	16.7257	5.494546	18.96476	7.01579	6.339397	19.0023		8.154459
2001Q3	16.37312	5.567434	18.79465	7.015697	6.31217	18.78725		8.088695
2001Q4	16.01862	5.641729	18.61989	7.015545	6.28534	18.57112		8.023325
2002Q1	15.66235	5.717734	18.43936	7.015311	6.258931	18.35374	14.10842	7.958411
2002Q2	15.30465	5.795738	18.25195	7.014969	6.232994	18.13502	13.95149	7.893999
2002Q3	14.94615	5.876018	18.05666	7.014501	6.207605	17.91495	13.79461	7.830096
2002Q4	14.58768	5.958828	17.85259	7.013896	6.182837	17.69352	13.63788	7.766662
2003Q1	14.23029	6.044405	17.63899	7.013149	6.158764	17.47081	13.48152	7.703615
2003Q2	13.87521	6.132966	17.41528	7.01225	6.135465	17.24695	13.3258	7.640846
2003Q3	13.52369	6.224706	17.18106	7.011189	6.113061	17.02212	13.171	7.578223
2003Q4	13.17704	6.319796	16.93605	7.00995	6.091714	16.79649	13.01745	7.515618
2004Q1	12.83653	6.41837	16.68018	7.008516	6.071638	16.57027	12.86559	7.452934
2004Q2	12.50339	6.52052	16.41357	7.006873	6.053074	16.34374	12.71599	7.390122
2004Q3	12.17884	6.626295	16.13655	7.005017	6.036291	16.11737	12.56921	7.327195
2004Q4	11.8641	6.735699	15.84969	7.002958	6.021578	15.89176	12.4259	7.264238
2005Q1	11.56033	6.848709	15.55373	7.000714	6.009234	15.66767	12.28685	7.201395
2005Q2	11.2687	6.965278	15.24957	6.998314	5.999576	15.44596	12.15289	7.138875

2005Q3	10.99031	7.085347	14.93832	6.995791	5.992958	15.22762	12.02491	7.076945
2005Q4	10.72619	7.208876	14.62132	6.993185	5.989739	15.01368	11.90384	7.015929
2006Q1	10.4773	7.335844	14.30007	6.990533	5.990319	14.80525	11.79067	6.956202
2006Q2	10.24452	7.466245	13.97628	6.987869	5.995172	14.6035	11.68642	6.898194
2006Q3	10.02865	7.600078	13.65172	6.985229	6.004804	14.40956	11.59207	6.84239
2006Q4	9.830421	7.737336	13.3282	6.982649	6.019737	14.22452	11.50859	6.789294
2007Q1	9.650491	7.878012	13.00752	6.980171	6.040477	14.04936	11.43698	6.739427
2007Q2	9.489423	8.022084	12.69139	6.977839	6.067488	13.88495	11.37817	6.693294
2007Q3	9.347638	8.169474	12.38139	6.975692	6.101184	13.73195	11.33297	6.651333
2007Q4	9.225382	8.320049	12.07889	6.973769	6.141895	13.59088	11.30195	6.613894
2008Q1	9.122734	8.47362	11.78506	6.972097	6.18985	13.46208	11.28544	6.581224
2008Q2	9.039561	8.629965	11.5008	6.970699	6.245168	13.34568	11.2837	6.553452
2008Q3	8.975519	8.788799	11.22674	6.969584	6.307867	13.24161	11.29685	6.530557
2008Q4	8.930041	8.949773	10.96318	6.968752	6.377834	13.14956	11.32478	6.512365
2009Q1	8.902312	9.112469	10.71014	6.968191	6.454819	13.06894	11.36717	6.498547
2009Q2	8.891263	9.276412	10.46736	6.967875	6.53842	12.99887	11.42346	6.488638
2009Q3	8.895617	9.441123	10.23433	6.967774	6.628127	12.93826	11.49294	6.4821
2009Q4	8.913918	9.606162	10.01039	6.967853	6.723386	12.88591	11.57471	6.478394
2010Q1	8.944593	9.77116	9.79474	6.96808	6.823626	12.84061	11.66773	6.477038
2010Q2	8.986009	9.935827	9.586494	6.968423	6.928249	12.80125	11.77083	6.47761
2010Q3	9.036561	10.09997	9.384763	6.968857	7.036652	12.76683	11.88274	6.479776
2010Q4	9.094714	10.26349	9.188659	6.96936	7.148267	12.73649	12.00225	6.483254
2011Q1	9.159026	10.42637	8.997304	6.96991	7.262544	12.7095	12.12816	6.487807
2011Q2	9.228209	10.58864	8.809847	6.97049	7.378972	12.68518	12.25931	6.493232
2011Q3	9.301118	10.75036	8.625466	6.971084	7.497096	12.66297	12.39462	6.499354
2011Q4	9.376743	10.91163	8.443386	6.97168	7.616506	12.6423	12.5331	6.506026
2012Q1	9.4542	11.07256	8.262907	6.972271	7.736833	12.6227	12.67384	6.513107
2012Q2	9.532759	11.23325	8.083437	6.972856	7.857778	12.60379	12.81601	6.520459
2012Q3	9.611867	11.39382	7.904497	6.973436	7.97907	12.58524	12.95897	6.527967
2012Q4	9.691156	11.55435	7.725744	6.974013	8.100488	12.56681	13.10221	6.535535

Source: Authors' calculation based on Kalman filter method applied on actual unemployment rates (Eurostat database)