

Empirical Verification of the Ability of selected Methods for estimating the NAIRU locate unstable Environment on the Labour Market

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Abstract

Application of **One-equation** model confirmed that one long-term NAIRU for the whole period did not capture the development in the labour market during unstable and transition periods (eg.the transition environment and recession period or let us say, conjuncture). Since the **Break model** in the monitored period separates out some time intervals, the estimated NAIRU better reflects the real situation in the labour market. **Kalman filter** with a higher coefficient of smoothing than is the commonly recommended value succeeded in capturing the non-stable environment in the labour market. We found these sources of instability and changes in labour market: the restructuring of the economy, change in nature of trade-off between unemployment rate and households' consumption deflator caused by factors exogenous to the labour market or by the global financial and economic crisis. The instability of economic environment can be represented by negative values of NAIRU. The experiences with non-stable environment in past can be used, under condition of anticipated expectations environment, to estimate it at the end of the examined period. Kalman filter can indicate the time leading between labour market development in various countries and be used for short-term prediction.

Keywords: Phillips curve; NAIRU; One equation model; Break model; Kalman filter and unemployment gap

JEL classification codes: E24, E32, E37

Introduction

The relationship between unemployment rate and inflation is very important indicator of

behaviour on the labour market (Richardson et al. 2000). Non-Accelerating Inflation Rate of Unemployment (NAIRU) is an unobservable variable which indicates the “equilibrium” or “expected” values of parameters (Boone 2000). Estrada et al. (2000) found out that alternative measurement instruments provide different estimates of the NAIRU. The article tries to find methods which are able to capture the fragile environment in the labour market and in the economy. The main issues, which are discussed in this article, are: location of instability, sources of instability, way of expression of instability of NAIRU, estimation of changes in the labour market in the near future and application of experiences from one country to another.

History of the concept and selected approaches

Humphrey (1985) stated that Phillips and his successors inherited the concept Phillips Curve (PC). Humphrey mentioned these predecessors of Phillips: Law, Thornton, Attwood, Mill, Fischer, Tinbergen, Klein and Goldberger, Brown and Sultan. Phillips (1958) stated that the rate of nominal wage change can be explained by the level of unemployment and by the rate of unemployment change. Samuelson and Solow (1960) considered that the relationship between the rate of price inflation and the rate of unemployment is unstable in the long run. Phelps (1967) was persuaded about a dynamic trade off relationship between unemployment and inflation. Friedman (1968) wrote about existence of a level of unemployment which is consistent with the equilibrium in structure of real wage rates. Modigliani and Papademos (1975) defined Non Inflation Rate of Unemployment (NIRU) as a rate of unemployment when a decline of inflation can be expected. Tobin (1997) developed Non-Accelerating Inflation Rate of Unemployment (NAIRU) as a result of macroeconomic settlement of pressures on the inflation growth from markets with an excessive demand and pressures on the inflation decrease from markets with an excessive supply.

Boone (2000) interpreted NAIRU as an unobservable variable which indicates the “equilibrium” or “expected” values of parameters to be estimated. Estrada et al. (2000) used a lot of methods and found out that alternative measurements provide different estimates of the NAIRU. In this analysis we use a methods which estimate one long ran NAIRU and NAIRU changed into several time intervals. Estimation of the one long ran NAIRU according to McAdam and McMorro (1999) can be performed by so called Gordon’s Triangle Model. There the inflation rate depends on inflation expectations, on demand conditions such as unemployment gap, and on supply shocks. In case of our analysis we will call the Gordon’s Triangle Model as the **One-equation model**. We obtained only one value of NAIRU for the whole examined period. In the context of the NAIRU changed into several time intervals

Fabiani and Mestre (2000) discuss the **Break model**. The breakpoint can be determined or estimated in advance. In case of estimation we can use the sequential algorithm where the first estimated breakpoint is considered fix and then follows estimation of the next breakpoint. Period in which the minimalization of the sum of the squares of the residua was the least we located Breakpoints. After this decomposition of the time series there were estimated straight lines by the method of least squares for all periods and calculated values of NAIRU (their statistical significance again decided the inclusion of the variables into the model).

Kalman filter belongs to the group of methods called Reduced form approach (Richardson et al. 2000). These methods use to estimate the NAIRU through behavioral equations explaining inflation (PC with expectations) and solving identification restrictions for the NAIRU estimated and the gap of unemployment. Among the advantages of this methods belongs, according to the authors, the direct connection of the NAIRU estimate with inflation. To the contrary the main disadvantage of this method is considered to be the absence of identification of basic structural relationships. Nevertheless, the filtration methods inside the system of these methods improve the NAIRU estimates comparing with other methods. Kalman filter is used by Fabiani and Mestre (2000). They added the assumption of changeability of NAIRU to the basic model of inflation equation. This assumption ensures that the NAIRU will move not far from the real unemployment. NAIRU is specified as a random walk. We present a series of alternative NAIRU which differ by value, which gives the smoothing level of the estimated NAIRU. As the Czech Republic (further Slovakia, Hungary and Poland too) are small open economies in transition, we have used smoothing at the level of 0,6 and 1,0 instead of standardly recommended value of 0,2. This ensured capturing of the variable development of unemployment.

Empirical testing selected methods on the data of the Czech Republic

We start our analysis by application of **One-equation model**. Year on year change of the household consumption deflator (in %) is our dependent variable, fix regressors are values for unemployment rate in % (with and without lag), lagged values for year on year changes in households' consumption deflator in % and values for year on year changes in exchange rates of domestic currencies of examined economies to EUR in % (with and without lag).

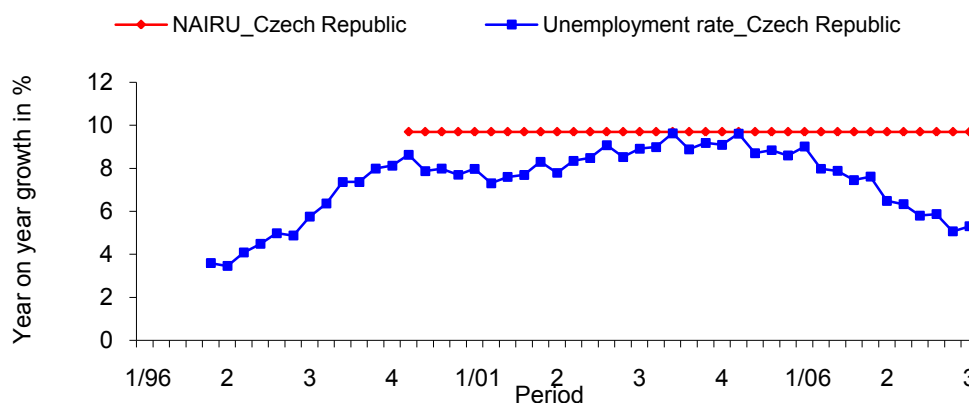
Table 1. Equations of curves obtained from One-equation model in the Czech Republic

Country	Equations of curves - method of least squares
Czech Republic	$\Delta\pi_t = 10,529 - 1,085u_{t-1} + 0,428\Delta\pi_{t-1} + 0,205x_t^{CZK/EUR} + 0,228x_{t-3}^{CZK/EUR} + e_t$

Note: Authors' calculation based on data obtained from the Czech National Bank and Czech Statistical Authority

Where π_t is the year on year change in households' consumption deflator in %, u_t stands for the rate of unemployment in %, X_t stands for the year on year change in exchange rate to EUR in %.

Figure 1. NAIRU development obtained from the One-equation model in the Czech Republic



Note: Authors' calculation based on data obtained from the Czech National Bank and Czech Statistical Authority

The estimated NAIRU in **the Czech Republic** was found equal to 9,7%. The NAIRU was far above the real rate of unemployment in the whole examined period. Slope of the line was standardly negative (- 1,1).

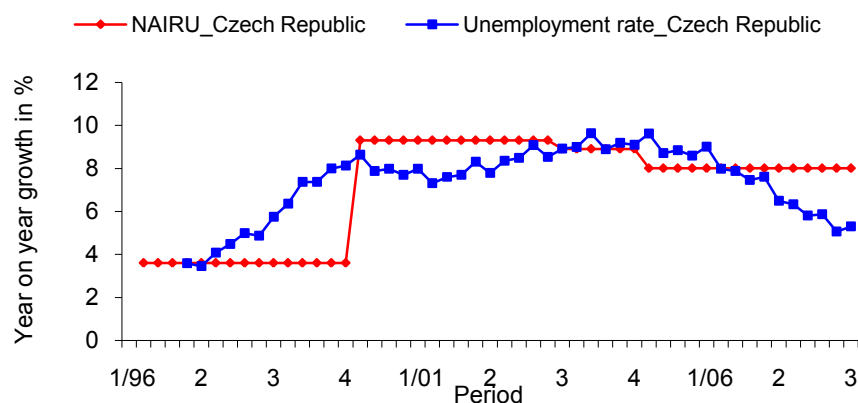
In this part we estimate the NAIRU in selected time periods through **the Break model**. Year on year change of the households' consumption deflator (in %) is our dependent variable, significant fix regressors are values for unemployment rate in % (with lagg), lagged values for year on year changes in households' consumption deflator in %, values for year on year changes in exchange rate of domestic currencies of examined economies to EUR in % (with and without lagg) and year on year changes in import prices with lagg.

Table 2. Equations of curves obtained from the Break model in the Czech Republic

Country	Equations of curves - method of least squares
Czech Republic	
1. interval	$\Delta\pi_t = 3,222 - 0,896u_{t-1} + 0,557\Delta\pi_{t-1} + 0,297x_t^{CZK/EUR} + e_t$
2. interval	$\Delta\pi_t = 13,801 - 1,481u_{t-1} + 0,251\Delta\pi_{t-1} + 0,266x_t^{CZK/EUR} + 0,300x_{t-3}^{CZK/EUR} + e_t$
3. interval	$\Delta\pi_t = 43,763 - 4,899u_{t-1} + 0,811\Delta\pi_{t-1} + 0,368x_t^{CZK/EUR} + 0,507x_{t-3}^{CZK/EUR} + e_t$
4. interval	$\Delta\pi_t = 17,054 - 2,119u_{t-1} + 0,619x_{t-1}^{Import p} + e_t$

Note: Authors' calculation based on data obtained from the Czech National Bank and Czech Statistical Authority

Where π_t is the year on year change in households' consumption deflator in %, u_t stands for the rate of unemployment in %, X_t stands for the year on year change in exchange rate to EUR in % and year on year change in import prices in %.

Figure 2. NAIRU development obtained from the Break model in the Czech Republic

Note: Authors' calculation based on data obtained from the Czech National Bank and Czech Statistical Authority

In the Czech Republic the whole period of time was divided into four intervals. The first interval starts in 2Q 1996 and ends in 4Q 1999. The second one lasts from 1Q 2000 until 2Q 2003, the third interval covers the period between 3Q 2003 and 4Q 2004 and the last one between 1Q 2005 and 3Q 2008. The break model estimated four values of NAIRU (3,6%, 9,3%, 8,9% and 8,0%). The estimated values of NAIRU responded more sensitively to the development of the real rate of unemployment. Slopes of the lines were negative in all time intervals.

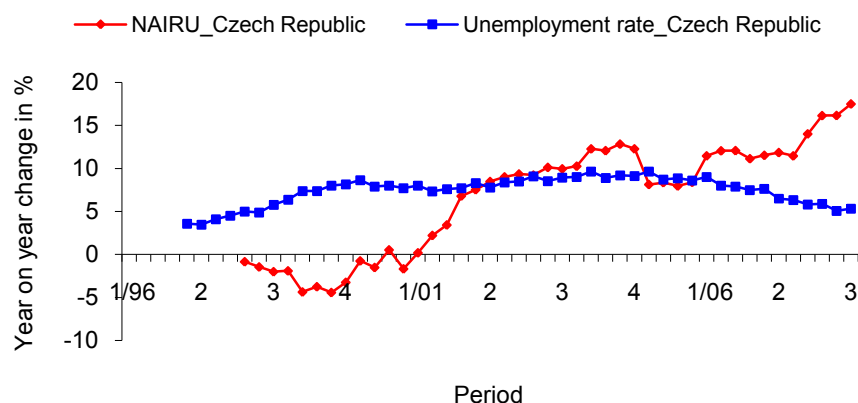
The Kalman filter provides variable values of NAIRU in each time interval. For both smoothings we used year on year change of the household consumption deflator (in %) as dependent variable, fix regressors were lagged values for unemployment rate in %, values for year on year changes in households' consumption deflator in % and values for year on year changes in exchange rate of domestic currencies to EUR in %. Year on year changes in import prices were significant without lag.

Table 3. Equations of curves obtained from Kalman filter in the Czech Republic

Country	Equations of curves - method of least squares
Czech Republic	
Smoothing 0,6	$\Delta\pi_t = SV1 - 0,713u_{t-2} + 0,306\Delta\pi_{t-2} + 0,316x_{t-2}^{CZK/EUR} + 0,292x_t^{Import\ p} + e_t$
Smoothing 1,0	$\Delta\pi_t = SV1 - 0,750u_{t-1} + 0,325x_{t-2}^{CZK/EUR} + 0,183x_t^{Import\ p} + e_t$

Note: Authors' calculation of parameters based on data obtained from the Czech National Bank and Czech Statistical Authority

Where π_t is the year on year change in households' consumption deflator in %, u_t stands for the rate of unemployment in %, X_t stands for the year on year change in exchange rate to EUR in % and year on year change in import prices in %.

Figure 3. NAIRU development obtained from Kalman filter in the Czech Republic

Note: Authors' calculation based on data obtained from the Czech National Bank and Czech Statistical Authority

In the **Czech Republic** the values of NAIRU after smoothing by 0,6 were lying between - 1,1 and + 13,4 % and after smoothing by 1,0 the values were lying between - 1,9 and + 13,9 %. The NAIRU acquired **negative values** in time interval from 1Q 1999 until 4Q 1999. The model reacted to sharp changes in the impact of restructuring of the domestic economy which caused unstability in trade off between unemployment and households' consumption deflator. But we can name some other important factors too: fluctuations in oil prices, exchange rate fluctuations, import prices and regulated prices. **The highest value of NAIRU** was estimated for 3Q 2008 (with smoothing by 0,6 we obtained value of 13,4 % and for τ 1,0 the value was 13,9 %). In this interval the declining rate of unemployment was accompanied by a deceleration in growth of households' consumption deflator. The change in trade-off between unemployment and inflation was caused by development of oil price, by development of import prices and by development of exchange rate CZK/EUR.

Empirical testing selected methods on the data of Slovakia

In **One-equation model** is year on year change of the household consumption deflator (in %) our dependent variable. Fix regressors are values for unemployment rate in % (without lag), lagged values for year on year changes in households' consumption deflator in % and values for year on year changes in exchange rates of domestic currencies of examined economies to EUR in % (with lag).

Table 4. Equations of curves obtained from One-equation model in Slovakia

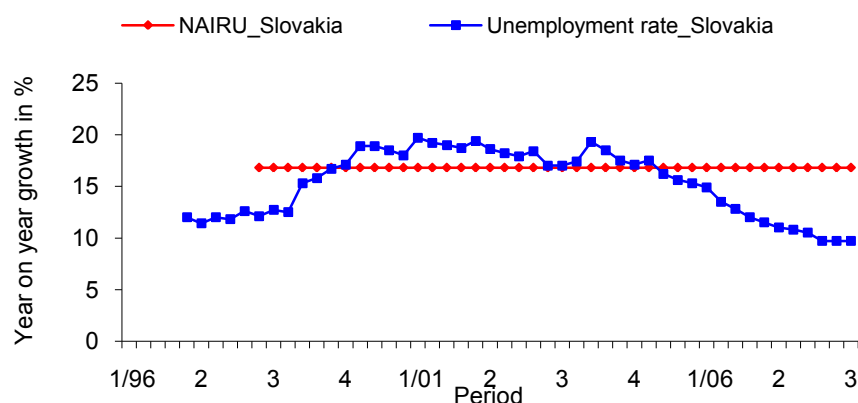
Country	Equations of curves - method of least squares
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Slovakia	$\Delta \pi_t = 4,984 - 0,296u_t + 0,608\Delta\pi_{t-1} + 0,163x_{t-1}^{SKK/EUR} + e_t$
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Note: Authors' calculation based on data obtained from OECD

Where π_t is the year on year change in households' consumption deflator in %, u_t stands for the rate of unemployment in % and X_t stands for the year on year change in exchange rate to EUR in %.

Figure 4. NAIRU development obtained from the One-equation model in Slovakia



Note: Authors' calculation based on data obtained from OECD

In **Slovakia** we found the value of NAIRU at 16,8% and it differed significantly from the real rate of unemployment only at the end of the examined period. Slope of the line was standardly negative (- 0,3).

In **Break model** is year on year change of the households' consumption deflator (in %) our dependent variable. Significant fix regressors are values for unemployment rate in % (with and without lag), lagged values for year on year changes in households' consumption deflator in %, values for year on year changes in exchange rate of domestic currencies of examined economies to EUR in % (with lag), year on year changes in oil prices (Brent) with and without lag and import prices with lag.

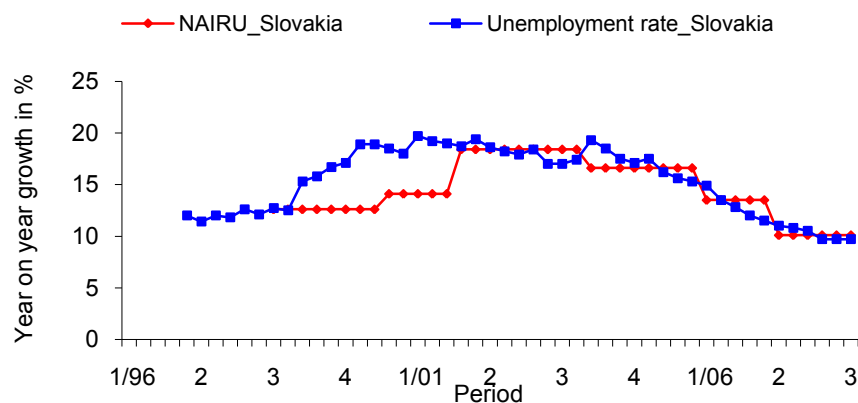
Table 5. Equations of curves obtained from the Break model in Slovakia

Country	Equations of curves - method of least squares
Slovakia	
1. interval	$\Delta\pi_t = 12,294 - 0,972u_{t-1} + 0,619x_{t-2}^{SKK/EUR} + 0,031x_t^{Oil\ p} + e_t$
2. interval	$\Delta\pi_t = 16,551 - 1,178u_t + 0,643x_{t-2}^{SKK/EUR} + 0,222x_{t-5}^{Import\ p} + e_t$
3. interval	$\Delta\pi_t = 34,880 - 1,898u_{t-1} + 0,049x_{t-2}^{Oil\ p} + e_t$
4. interval	$\Delta\pi_t = 19,969 - 1,200u_{t-3} + 0,708\Delta\pi_{t-1} + e_t$
5. interval	$\Delta\pi_t = - 21,258 + 1,570u_{t-2} + e_t$
6. interval	$\Delta\pi_t = 42,477 - 4,220u_t + 0,298x_{t-3}^{Import\ p} + e_t$

Note: Authors' calculation based on data obtained from OECD

Where π_t is the year on year change in households' consumption deflator in %, u_t stands for the rate of unemployment in %, X_t stands for the year on year change in exchange rate to EUR in %, year on year change in oil price (Brent) and year on year change in import prices in %.

Figure 5. NAIRU development obtained from the Break model in Slovakia



Note: Authors' calculation based on data obtained from OECD

In **Slovakia** we obtained three breakpoints in NAIRU development. Trade off between unemployment and deflator was divided into six time intervals as follows: 3Q 1998 – 2Q 2000, 3Q 2000 – 3Q 2001, 4Q 2001 – 4Q 2003 and so on. The Break model estimated in total six intervals in which the NAIRU amounted to the following values (in time order): 12,6 %, 14,1 %, 18,4 %, 16,6 %, 13,5 % a 10,1 %. The Slovak economy was in a boom phase from the 1Q 2008 until the end of the estimated period. Slopes of the lines are standardly negative, except from the fifth interval.

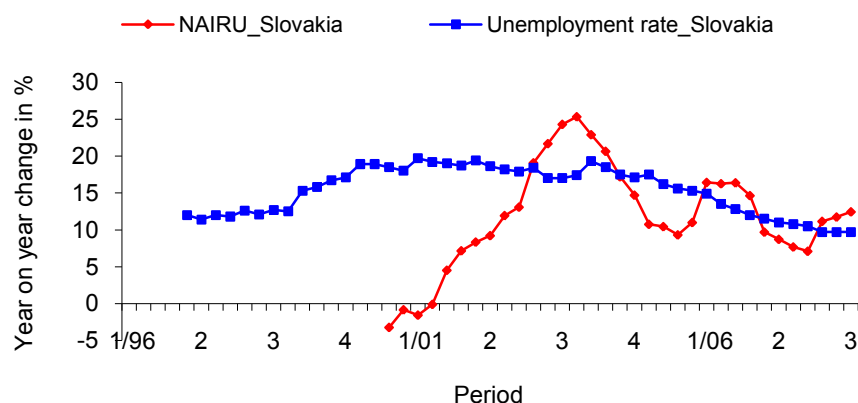
The Kalman filter (for both smoothings) used year on year change of the household consumption deflator (in %) as dependent variable, fix regressors were lagged values for unemployment rate in %, values for year on year changes in households' consumption deflator in % and year changes in exchange rate of oil prices (Brent).

Table 6. Equations of curves obtained from Kalman filter in Slovakia

Country	Equations of curves - method of least squares
Slovakia	
Smoothing 0,6	$\Delta\pi_t = SV1 - 0,307u_{t-4} + 0,483\Delta\pi_{t-1} + 0,026x_{t-6}^{Oil\ p} + e_t$
Smoothing 1,0	$\Delta\pi_t = SV1 - 0,377u_{t-4} + 0,418\Delta\pi_{t-1} + 0,029x_{t-6}^{Oil\ p} + e_t$

Note: Authors' calculation based on data obtained from OECD

Where π_t is the year on year change in households' consumption deflator in %, u_t stands for the rate of unemployment in % and X_t stands for the year on year change in oil price (Brent).

Figure 6. NAIRU development obtained from Kalman filter in Slovakia

Note: Authors' calculation based on data obtained from OECD

In **Slovakia** the values of NAIRU after smoothing by 0,6 were lying between - 3,3 and + 25,3 % and after smoothing by 1,0 the values were lying between - 2,9 and + 25,8 %. **Negative values of NAIRU** were found out in the interval between 3Q 2000 and 2Q 2001. Decisive factor for it was the restructuring of the Slovak economy from 1999. There were high fluctuations in oil prices, exchange rate fluctuations and decline in import prices. Real economy variables development in 3Q 2008 did not signal unstable environment nor structural shifts which could increase the NAIRU value in the next period.

Empirical testing selected methods on the data of Hungary

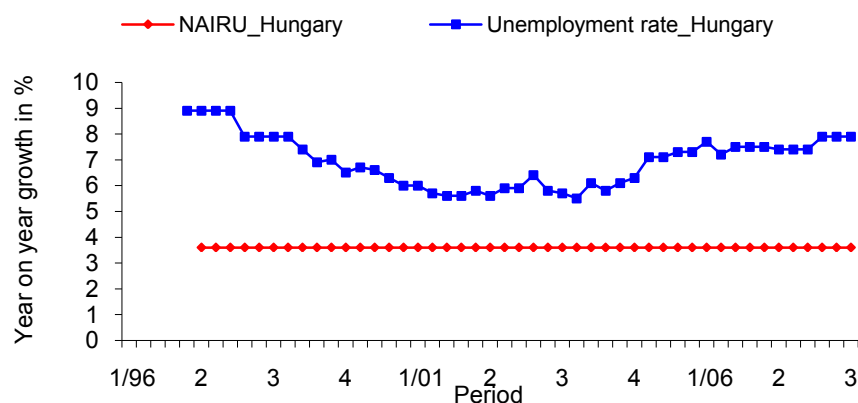
In **One-equation model** is year on year change of the household consumption deflator (in %) our dependent variable. Fix regressors are values for unemployment rate in % (with lagg), lagged values for year on year changes in households' consumption deflator in % and year on year changes in oil price (Brent) without lagg.

Table 7. Equations of curves obtained from One-equation model in Hungary

Country	Equations of curves - method of least squares
Hungary	$\Delta\pi_t = 1,248 - 0,348u_{t-9} + 0,419\Delta\pi_{t-1} + 0,024x_t^{Oil p} + e_t$

Note: Authors' calculation based on data obtained from OECD

Where π_t is the year on year change in households' consumption deflator in %, u_t stands for the rate of unemployment in % and X_t stands for the year on year change in oil price (Brent)

Figure 7. NAIRU development obtained from the One-equation model in Hungary

Note: Authors' calculation based on data obtained from OECD

For **Hungary** the model estimated the NAIRU at 3,6%. Slope of the line was standardly negative (- 0,3). The NAIRU lied far below the real rate of unemployment in the whole period of time.

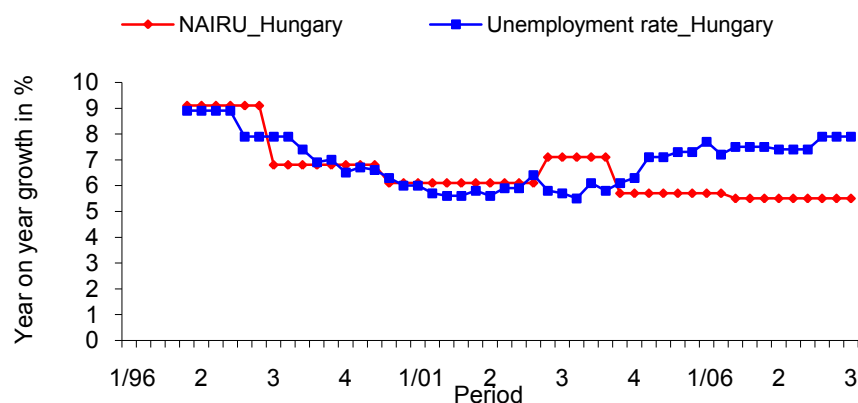
In **the Break model** is year on year change of the households' consumption deflator (in %) our dependent variable. Significant fix regressors are values for unemployment rate in % (with lag), values for year on year changes in exchange rate of domestic currencies of examined economies to EUR in % (with and without lag) and year on year changes in oil prices (Brent) with and without lag.

Table 8. Equations of curves obtained from the Break model in Hungary

Country	Equations of curves - method of least squares
Hungary	
1. interval	$\Delta\pi_t = 49,368 - 5,434u_{t-7} + 0,114x_t^{HUF/EUR} + 0,046x_t^{Oil\ p} + e_t$
2. interval	$\Delta\pi_t = 36,572 - 5,391u_{t-1} + 0,122x_t^{HUF/EUR} + e_t$
3. interval	$\Delta\pi_t = 29,578 - 4,864u_{t-8} + 0,074x_{t-2}^{Oil\ p} + e_t$
4. interval	$\Delta\pi_t = 43,018 - 6,081u_{t-3} + 1,555x_{t-6}^{HUF/EUR} + e_t$
5. interval	$\Delta\pi_t = 23,494 - 4,118u_{t-8} + e_t$
6. interval	$\Delta\pi_t = 30,278 - 4,018u_{t-2} + 0,391x_{t-4}^{HUF/EUR} + e_t$

Note: Authors' calculation based on data obtained from OECD

Where π_t is the year on year change in households' consumption deflator in %, u_t stands for the rate of unemployment in %, X_t stands for the year on year change in exchange rate to EUR in % and year on year change in oil price (Brent).

Figure 8. NAIRU development obtained from the Break model in Hungary

Note: Authors' calculation based on data obtained from OECD

In **Hungary** the model detected three breakpoints (2Q 1998, 1Q 2003 and 2Q 2006) and six time intervals. In the first interval the value of NAIRU was 9,1 %, in the second period it was 6,8%, in the third one 6,1 %, then 7,1 %, 5,7 % and finally 7,5 % in the sixth period. The deducted NAIRU was below the real rate of unemployment between 1Q 2001 and 3Q 2008. Slopes of the lines are standardly negative.

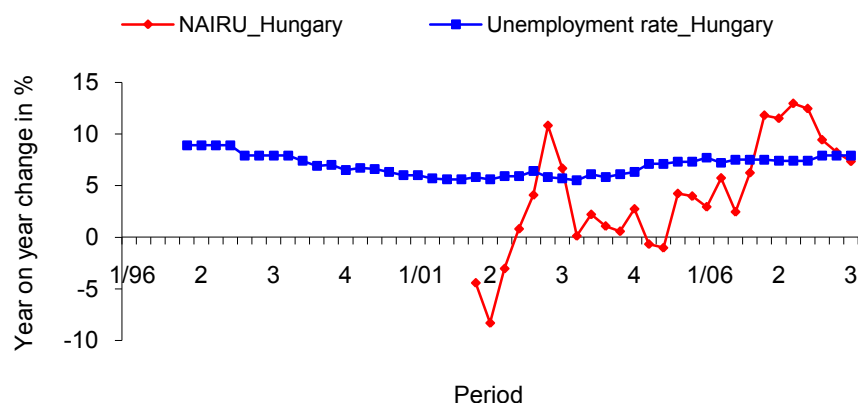
The Kalman filter (for both smoothings) used year on year change of the household consumption deflator (in %) as dependent variable, fix regressors were lagged values for unemployment rate in % and values for year on year changes in households' consumption deflator in %.

Table 9. Equations of curves obtained from Kalman filter in Hungary

Country	Equations of curves - method of least squares
Hungary	
Smoothing 0,6	$\Delta\pi_t = SV1 - 0,206u_{t-11} + 0,303\Delta\pi_{t-1} + e_t$
Smoothing 1,0	$\Delta\pi_t = SV1 - 0,317u_{t-8} + 0,256\Delta\pi_{t-1} + e_t$

Note: Authors' calculation based on data obtained from OECD

Where π_t is the year on year change in households' consumption deflator in % and u_t stands for the rate of unemployment in %.

Figure 9. NAIRU development obtained from Kalman filter in Hungary

Note: Authors' calculation based on data obtained from OECD

In **Hungary** the values of NAIRU after smoothing by 0,6 were lying between - 8,3 and + 12,9 % and after smoothing by 1,0 between - 6,3 and + 12,4 %. **Negative values of NAIRU** were estimated between 1Q and 3Q 2002. During this interval the characteristics of trade-off between unemployment and households' consumption deflator changed. Main factors influencing this change were exchange rate HUF/EUR, oil price and import prices. **Highest values of NAIRU** from the whole examined period were found between 1Q and 4Q 2007 (after smoothing by 0,6 amounted to 12,2 % and after smoothing by 1,0 amounted to 11,8 %). The rate of unemployment stagnated more or less at the level of 2006, but was accompanied by a significant increase in growth dynamics of households' consumption deflator. The change in trade-off between unemployment and households' consumption deflator was caused mainly by oil price (Brent) development. During 3Q 2008 the **NAIRU really decreased under the level of real rate of unemployment** which was impact of the global financial and economic crisis.

Empirical testing selected methods on the data of Poland

In **One-equation model** is year on year change of the household consumption deflator (in %) our dependent variable. Fix regressors are values for unemployment rate in % (without lag), lagged values for year on year changes in households' consumption deflator in %, year on year changes in oil price (Brent) and import prices without lag.

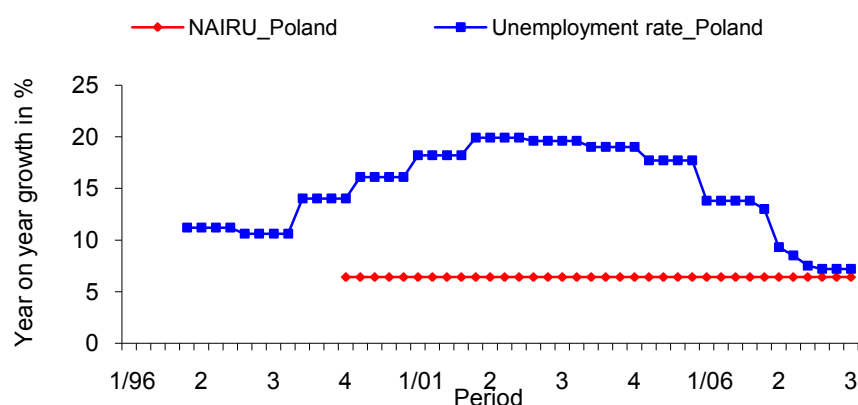
Table 10. Equations of curves obtained from One-equation model in Poland

Country	Equations of curves - method of least squares
Poland	$\Delta\pi_t = 0,922 - 0,144u_t + 0,494\Delta\pi_{t-1} + 0,016x_t^{\text{Oil } p} + 0,239x_t^{\text{Import } p} + e_t$

Note: Authors' calculation based on data obtained from OECD

Where π_t is the year on year change in households' consumption deflator in %, u_t stands for the rate of unemployment in %, X_t stands for the year on year change in oil price (Brent) and year on year change in import prices in %.

Figure 10. NAIRU development obtained from the One-equation model in Poland



Note: Authors' calculation based on data obtained from OECD

In **Poland** the NAIRU found amounted to 6,4%. This method estimated unrealistically high gap of unemployment with desinflation impulses until the 2Q 2007. Slope of the line is negative (- 0,1).

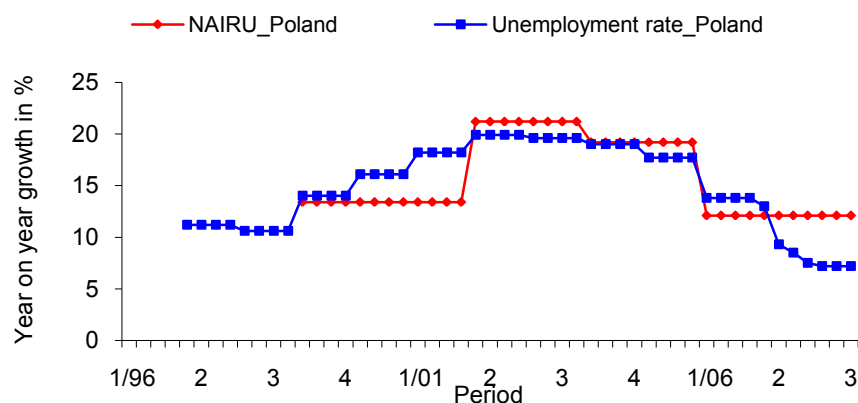
In **the Break model** is year on year change of the households' consumption deflator (in %) our dependent variable. Significant fix regressors are values for unemployment rate in % (with and without lagg) and year on year changes in oil prices (Brent) with lagg.

Table 11. Equations of curves obtained from the Break model in Poland

Country	Equations of curves - method of least squares
Poland	
1. interval	$\Delta\pi_t = -22,364 + 1,673u_{t-6} + 0,051x_{t-1}^{\text{Oil } p} + e_t$
2. interval	$\Delta\pi_t = -30,328 + 1,432u_{t-1} + e_t$
3. interval	$\Delta\pi_t = -79,421 + 4,135u_{t-5} + e_t$
4. interval	$\Delta\pi_t = 4,127 - 0,340u_t + e_t$

Note: Authors' calculation based on data obtained from OECD

Where π_t is the year on year change in households' consumption deflator in %, u_t stands for the rate of unemployment in % and X_t stands for the year on year change in oil price (Brent).

Figure 11. NAIRU development obtained from the Break model in Poland

Note: Authors' calculation based on data obtained from OECD

In **Poland** model estimated two breakpoints (4Q 2000 and 4Q 2005) and four time intervals. The NAIRU estimated was as follows: 13,4 %, 21,2 %, 19,2 % and 12,1 %. Values of NAIRU copy the development of the real rate of unemployment until 2Q 2007. In the following period the NAIRU was found significantly above the real rate of unemployment. The peak of the economic boom phase was identified in 2008. Slopes of the lines are untypically positive (except from the last interval).

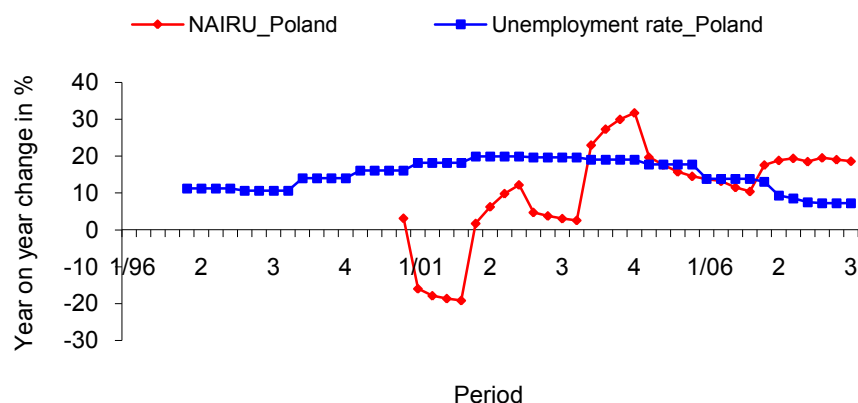
The Kalman filter (for both smoothings) used year on year change of the household consumption deflator (in %) as dependent variable, fix regressors were lagged values for unemployment rate in %, values for year on year changes in households' consumption deflator in %. Year on year changes in import prices were significant without lag.

Table 12. Equations of curves obtained from Kalman filter in Poland

Country	Equations of curves - method of least squares
Poland	
Smoothing 0,6	$\Delta\pi_t = SV1 - 0,090u_{t-2} + 0,443\Delta\pi_{t-1} + e_t$
Smoothing 1,0	$\Delta\pi_t = SV1 - 0,340u_{t-3} + 0,293x_t^{\text{Import p}} + e_t$

Note: Authors' calculation based on data obtained from OECD

Where π_t is the year on year change in households' consumption deflator in %, u_t stands for the rate of unemployment in % and X_t stands for the year on year change in import prices in %.

Figure 12. NAIRU development obtained from Kalman filter in Poland

Note: Authors' calculation based on data obtained from OECD

In **Poland** the values of NAIRU after smoothing by 0,6 were lying between - 19,2 and + 31,7 % and after smoothing by 1,0 between - 2,8 and + 22,4 %. **Negative values of NAIRU** in the period between 1Q and 4Q 2001 were result of domestic economy restructuring and of oil price fluctuations and import prices fluctuations. **Highest values of NAIRU** were found between 1Q and 4Q 2004. These values were highly influenced by the implemented restructuring of the domestic economy in the previous period, oil price fluctuations and exchange rate PLN/EUR development. **High values of unemployment gap** and related signals of possible structural shifts in the labour market in next periods (caused by global financial and economic crisis) can be observed also from 2Q 2007 till 3Q 2008.

Summary

Application of **One-equation model** confirmed that one long-term NAIRU for the whole period did not capture the development in the labour market during unstable and transition periods (eg.the transition environment and recession period or let us say, conjuncture). Regarding the fact that NAIRU is a long-term average of real rates of unemployment, and the real rate of unemployment in the previous period was higher than in the monitored period, the NAIRU in **the Czech Republic** was far above the real rate of unemployment in the whole examined period. Since the **Break model** in the monitored period separates out some time intervals, the estimated NAIRU better reflects the real situation in the labour market. In **the Czech Republic** the whole period was divided into four intervals (there were thus estimated two breakpoints). The estimated values of NAIRU responded sensitively to the development

of the real rate of unemployment. **Kalman filter** with a higher coefficient of smoothing than is the commonly recommended value succeeded in capturing the non-stable environment in the labour market. The NAIRU acquired negative values in time when the model reacted to sharp changes in the impact of restructuring of the domestic economy. We can name some other factors too: fluctuations in oil prices, exchange rate fluctuations, import prices and regulated prices. In time with the highest value of NAIRU the declining rate of unemployment was accompanied by a deceleration in growth of households' consumption deflator. The change in trade-off between unemployment and inflation was caused by development of oil price, by development of import prices and by development of exchange rate CZK/EUR.

In **Slovakia** the values of NAIRU with application of **One-equation model** were differed significantly from the real rate of unemployment only at the end of the examined period. In **Slovakia** the **Break model** estimated three breakpoints in NAIRU development (six time periods). According to this methodology the Slovak economy was in a boom phase from the 1Q 2008 until the end of the estimated period. Negative values of NAIRU from **Kalman filter** were caused by the restructuring of the Slovak economy from 1999. There were high fluctuations in oil prices, exchange rate fluctuations and decline in import prices. Real economy variables development in 3Q 2008 did not signal unstable environment nor structural shifts which could increase the NAIRU value in the next period.

In **Hungary** the NAIRU with application of **One-equation model** lied far below the real rate of unemployment in the whole period of time. In Hungary the **Break model** detected three breakpoints and six time intervals. The deducted NAIRU was below the real rate of unemployment between 1Q 2001 and 3Q 2008. Negative values of NAIRU from **Kalman filter** caused change of trade-off between unemployment and households' consumption deflator. Main factors influencing this change were exchange rate HUF/EUR, oil price and import prices. Highest values of NAIRU from the whole examined period were found between 1Q and 4Q 2007 when the change in trade-off between unemployment and households' consumption deflator was caused by oil price (Brent) development.

In **Poland** the **One-equation model** estimated unrealistically high gap of unemployment with desinflation impulses until the 2Q 2007. In Poland the **Break model** estimated two breakpoints and four time intervals. Values of NAIRU copy the development of the real rate of unemployment until 2Q 2007. In the following period the NAIRU was found significantly above the real rate of unemployment. The peak of the economic boom phase was identified in 2008. Negative values of NAIRU from **Kalman filter** were result of domestic economy restructuring and of oil price fluctuations and import prices fluctuations. Highest

values of NAIRU were influenced by the implemented restructuring of the domestic economy in the previous period, by oil price fluctuations and exchange rate PLN/EUR development and by influence of financial and economic crises.

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Appendix 1. Survey of parameters, P-values and selected characteristics of models for the Czech Republic

Name of the method	Parameter of the model	Value	P-value	Selected charact. of the model		
				R-squared	Durbin-Watson stat.	Prob (F-stat)
One-equation model	Constant	10,53	0,00			
	Rate of unemployment (t-1)	-1,09	0,00			
	Consumption deflator (t-1)	0,43	0,00			
	Exchange rate (t)	0,21	0,00			
	Exchange rate (t-3)	0,23	0,01			
	Characteristics of the model			0,73	1,52	0,00
Break model	1. interval	Constant	3,22	0,10		
		Rate of unemployment (t-1)	-0,90	0,06		
		Consumption deflator (t-1)	0,56	0,01		
		Exchange rate (t)	0,30	0,02		
		Characteristics of the model		0,81	1,67	0,00
	2. interval	Constant	13,80	0,07		
		Rate of unemployment (t-1)	-1,48	0,10		
		Consumption deflator (t-1)	0,25	0,10		
		Exchange rate (t)	0,27	0,01		
		Exchange rate (t-3)	0,30	0,00		
		Characteristics of the model		0,85	2,00	0,00
	3. interval	Constant	43,76	0,03		
		Rate of unemployment (t-1)	-4,90	0,03		
		Consumption deflator (t-1)	0,81	0,05		
		Exchange rate (t)	0,37	0,06		
		Exchange rate (t-3)	0,51	0,02		
		Characteristics of the model		0,99	2,00	0,02
	4. interval	Constant	17,05	0,00		
		Rate of unemployment (t-1)	-2,12	0,00		
		Import prices (t-1)	0,62	0,05		
		Characteristics of the model		0,75	1,98	0,00
Kalman filter Smoothing (0,6)	Constant	9,52	0,00			
	Rate of unemployment (t-2)	-0,71	0,00			
	Consumption deflator (t-2)	0,31	0,00			

Smoothing (1,0)	Exchange rate (t-2)	0,32	0,00			
	Import prices (t)	0,29	0,00			
	Characteristics of the model			0,90	2,00	x
	Constant	10,41	0,00			
	Rate of unemployment (t-1)	-0,75	0,03			
	Exchange rate (t-2)	0,33	0,00			
	Import prices (t)	0,18	0,05			
	Characteristics of the model			0,92	1,98	x

Note: Authors' calculation of parameters based on data obtained from the Czech National Bank and Czech Statistical Authority

Appendix 2. Survey of parameters, P-values and selected characteristics of models for Slovakia

Name of the method	Parameter of the model	Value	P-value	Selected charact. of the model		
				R-squared	Durbin-Watson stat.	Prob (F-stat)
One-equation model	Constant	4,98	0,06			
	Rate of unemployment (t)	-0,30	0,07			
	Consumption deflator (t-1)	0,61	0,00			
	Exchange rate (t-1)	0,16	0,03			
	Characteristics of the model			0,56	1,67	0,00
Break model	1. interval	Constant	12,29	0,10		
		Rate of unemployment (t-1)	-0,97	0,10		
		Exchange rate (t-2)	0,62	0,09		
		Oil price (t)	0,03	0,07		
		Characteristics of the model		0,88	1,56	0,03
	2. interval	Constant	16,55	0,10		
		Rate of unemployment (t)	-1,18	0,10		
		Exchange rate (t-2)	0,64	0,04		
		Import prices (t-5)	0,22	0,05		
		Characteristics of the model		0,90	1,99	0,05
	3. interval	Constant	34,88	0,05		
		Rate of unemployment (t-1)	-1,90	0,05		
		Oil price (t-2)	0,05	0,09		
		Characteristics of the model		0,82	1,96	0,01
	4. interval	Constant	19,97	0,10		

5. interval	Rate of unemployment (t-3)	-1,20	0,10			
	Consumption deflator (t-1)	0,71	0,01			
	Characteristics of the model			0,84	2,00	0,01
	Constant	-21,26	0,06			
6. interval	Rate of unemployment (t-2)	1,57	0,05			
	Characteristics of the model			0,76	1,95	0,05
	Constant	42,48	0,01			
	Rate of unemployment (t)	-4,22	0,01			
6. interval	Import prices (t-3)	0,30	0,10			
	Characteristics of the model			0,90	2,00	0,00
Kalman filter Smoothing (0,6)	Constant	3,81	0,01			
	Rate of unemployment (t-4)	-0,31	0,00			
	Consumption deflator (t-1)	0,48	0,00			
	Oil price (t-6)	0,03	0,01			
	Characteristics of the model			0,80	1,58	x
Smoothing (1,0)	Constant	4,85	0,00			
	Rate of unemployment (t-4)	-0,38	0,00			
	Consumption deflator (t-1)	0,42	0,00			
	Oil price (t-6)	0,03	0,00			
	Characteristics of the model			0,89	1,55	x

Note: Authors' calculation of parameters based on data obtained from OECD

Appendix 3. Survey of parameters, P-values and selected characteristics of models for Hungary

Name of the method	Parameter of the model	Value	P-value	Selected charact. of the model		
				R-squared	Durbin-Watson stat.	Prob (F-stat)
One-equation model	Constant	1,25	0,10			
	Rate of unemployment (t-9)	-0,35	0,10			
	Consumption deflator (t-1)	0,42	0,02			
	Oil price (t)	0,02	0,01			
	Characteristics of the model			0,50	2,00	0,00
Break model 1. interval	Constant	49,37	0,10			
	Rate of unemployment (t-7)	-5,43	0,09			
	Exchange rate (t)	0,11	0,03			

2. interval	Oil price (t)	0,05	0,10			
	Characteristics of the model			0,96	1,81	0,07
	Constant	36,57	0,00			
	Rate of unemployment (t-1)	-5,39	0,00			
3. interval	Exchange rate (t)	0,12	0,02			
	Characteristics of the model			0,94	2,00	0,00
	Constant	29,58	0,03			
	Rate of unemployment (t-8)	-4,86	0,02			
4. interval	Oil price (t-2)	0,07	0,01			
	Characteristics of the model			0,62	1,98	0,02
	Constant	43,02	0,08			
	Rate of unemployment (t-3)	-6,08	0,10			
5. interval	Exchange rate (t-6)	1,56	0,03			
	Characteristics of the model			0,96	2,00	0,05
	Constant	23,49	0,10			
	Rate of unemployment (t-8)	-4,12	0,10			
6. interval	Characteristics of the model			0,59	1,95	0,09
	Constant	30,28	0,10			
	Rate of unemployment (t-2)	-4,02	0,10			
	Exchange rate (t-4)	0,39	0,01			
Kalman filter Smoothing (0,6)	Characteristics of the model			0,73	2,00	0,02
	Constant	1,51	0,10			
	Rate of unemployment (t-11)	-0,21	0,10			
	Consumption deflator (t-1)	0,3	0,10			
Smoothing (1,0)	Characteristics of the model			0,51	1,99	x
	Constant	2,28	0,10			
	Rate of unemployment (t-8)	-0,32	0,10			
	Consumption deflator (t-1)	0,26	0,10			
	Characteristics of the model			0,51	2,00	x

Note: Authors' calculation of parameters based on data obtained from OECD

Appendix 4. Survey of parameters, P-values and selected characteristics of models for

Poland

Name of the method	Parameter of the model	Selected charact. of the model				
		Value	P-value	R-squared	Durbin-Watson stat.	Prob (F-stat)

One-equation model	Constant	0,92	0,10			
	Rate of unemployment (t)	-0,14	0,10			
	Consumption deflator (t-1)	0,49	0,00			
	Oil price (t)	0,02	0,10			
	Import prices (t)	0,24	0,05			
	Characteristics of the model			0,51	1,73	0,00
Break model	1. interval	Constant	-22,36	0,01		
		Rate of unemployment (t-6)	1,67	0,02		
		Oil price (t-1)	0,05	0,01		
		Characteristics of the model			0,86	2,00
	2. interval	Constant	-30,33	0,01		
		Rate of unemployment (t-1)	1,43	0,01		
		Characteristics of the model			0,51	1,56
	3. interval	Constant	-79,42	0,02		
		Rate of unemployment (t-5)	4,14	0,02		
		Characteristics of the model			0,62	2,00
	4. interval	Constant	4,13	0,00		
		Rate of unemployment (t)	-0,34	0,00		
		Characteristics of the model			0,80	1,83
Kalman filter	Smoothing (0,6)	Constant	1,67	0,10		
		Rate of unemployment (t-2)	-0,09	0,10		
		Consumption deflator (t-1)	0,44	0,10		
		Characteristics of the model			0,63	1,95
	Smoothing (1,0)	Constant	4,29	0,00		
		Rate of unemployment (t-3)	-0,34	0,01		
		Import prices (t)	0,29	0,01		
		Characteristics of the model			0,93	2,01

Note: Authors' calculation of parameters based on data obtained from OECD