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EVALUATION OF THE USE OF METHODS FOR THE TIME VARYING NAIRU AND ECONOMIC CYCLE ESTIMATION FROM THE PERSPECTIVE OF THE V4 COUNTRIES REAL ECONOMY DATA

Abstract:

The aim of the paper is to apply a set of internationally used methods to estimate NAIRU in countries of the Visegrad Group. The analysis is focused on estimation of the time varying NAIRU that best describes development in the countries during a period of transition from one political-economic system to another and development in a period of major fluctuations in the economy as well as those caused by the financial, economic and debt crisis. Our attention was paid to localization of unstable period, the reasons for their creation, their way of expression and the duration on the labour market. The Stochastic method in the Czech Republic point the remarkable negative unemployment gap in period from the 4th quarter of 1996 to the 1st quarter of 1998. The authors analysed the ability of the methods to estimate the influence of V4 countries economy transformation in accordance with the real data.

Keywords:

Phillips curve; NAIRU; HP filter; Kalman filter; Stochastic trend; Unemployment gap.

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Introduction

Economists are often interested in estimates of unobservable variables representing “balanced” or “expected” values of studied quantities (**Boone, 2000**). Further investigation leads to comparison of trend quantity with the real one and to the expression of so-called gap. Such significant variables include NAIRU (Non-Accelerating Inflation Rate of Unemployment) and the gap between NAIRU and the real unemployment rate. They are both used in economic policy for evaluation of demand-pull inflationary pressures as well as for conceiving labour market measures (**Estrada et al., 2000**). The fundamental question is whether the real unemployment rate is above or below the level representing inflation stability in the form of NAIRU.

Since NAIRU is not a directly observable quantity, it must be quantified using appropriate methods **(Boone, 2000**). Deviations in NAIRU values according to used methods are important. Moreover, they vary by country and even in time within one country. **Estrada et al.** (2000) see estimates as a kind of interval for possible movement of NAIRU and not as a point estimate. At the current level of our knowledge of this issue, they classify the usefulness of the NAIRU concept in macroeconomic policy as very limited.

However, authors as **McAdam and McMorrow** (1999) think there are strong reasons for using NAIRU as for example an indicator when comparing the labour market flexibility in various countries and an indicator of malfunction of a certain labour market and therefore an instrument for setting structural reforms in relevant countries. **Richardson et al.** (2000) even suggest estimating NAIRU using three groups of methods.

The first objective of this analysis was to apply internationally used methods to conditions of countries that are characterized by permanently unstable environment, the reasons for that being either associated with development of the region (e.g. transition from one political-economic system to another) or having global nature (mainly the influence of financial, economic and debt recession). Based on our previous research, in this context we decided to estimate NAIRU using the Hodrick-Prescott filter (HP filter), the Kalman filter and the method of stochastic trend. We also focused on calculation of unemployment gaps in the Visegrad group (V4) countries labour market, which show the position within the economic cycle on the labour market. Identified phases of the economic cycle on the labour market were verified by development of the basic indicator of the real economy, i.e. the employment rate and GDP growth. In the next phase we identified unstable periods on the labour market in selected V4 countries. We assessed them especially in terms of the character of their expression, speed, intensity and duration on the labour market. The periods taken into account were mainly the period of economic transition, period of large positive unemployment gaps between 2007 and 2008, period of the Great recession and the end of the analyzed period.

The text is divided into following parts: the first part presents a brief overview of the development of conceptual framework of substitution between inflation and unemployment. The second part defines three groups of NAIRU estimation methods and considers in detail those that are addressed in the empirical part of the paper – that are those providing time-varying NAIRU. The third part provides application of methods of NAIRU estimation on V4 member states accompanied by a summary of results for each method. The results of individual countries analyses and methods are listed in the Conclusion.

1. Short overview of the substitution between inflation and unemployment conception development

Humphrey (1985) identifies three groups of authors dealing with substitution between price development and labour market development. He names these authors as predecessors of Phillips: Law, Thornton, Attwood, Mill, Fischer, Tinbergen, Klein and Goldberger, Brown, Sultan. According to Humprey the modern founder of the Phillips curve (PC) is **Phillips** (1958). As his successors he sees among others **Samuelson and Solow** (1960), **Phelps** (1967), **Friedman** (1968), **Modigliani and Papademos** (1975).

This material applies the concept of NAIRU, whose author is considered to be **Tobin** (1997). In his opinion, NAIRU is a result of macroeconomic balancing of pressures on inflation growth of excess demand markets and pressures on inflation decrease of excess supply markets. **Akerlof et al.** (1996) participated in extension of the notion. According to them NAIRU is the unemployment that ensures the balance between unemployment and real wages rates in the economy. The PC (Phillips Curve) model was extended by **Ball and Moffitt** (2001) by a gap between the labour productivity growth and the growth in average real wages.

2. Model approaches to NAIRU estimation

The concept of NAIRU is derived from an analysis of observable variables associated with its definition (**Fabiani and Mestre, 2000**). To estimate NAIRU, it is necessary to apply econometric methods. According to authors (**Richardson et al., 2000**), there are three groups of methods. The first group is Structural methods. The second one is called Purely statistical methods. The last group of NAIRU estimation methods consists of so-called Reduced forms approach.

Structural methods use theoretical apparatus to assess the influence of macroeconomic shocks and policies on structural unemployment (**Richardson et al., 2000**). NAIRU estimated by this group of methods is characterized by a high degree of uncertainty. Firstly, there is no agreement on the appropriate structural model (the discrepancy between theoretical and empirical view of the long-term effects of changes in real interest rates, taxes and productivity growth in relation to real wages and unemployment balance). Secondly, there is a generally specified problem with structural modelling (number and identity of explanatory variables, sensitivity of the results of a subset of variables chosen for insertion into the model). Thirdly, there is a statistical and identification problem (setting wages and prices equations estimation). As for disadvantages of this group of methods we can mention the problem of quantifying some institutional variables (such as unemployment benefits, employment protection legislation and the degree of unionization). **McAdam and McMorrow** (1999) specifically count in this group Gordon's "Triangle" model, a simple inflation system equation, as well as a wage-price equation system called the Bargaining model. These methods are not used here due to the large amount of uncertainty in relation to NAIRU estimate and unreliability of estimations in the conditions of V4 countries that has been identified by previous research (**Kadeřábková and Jašová, 2012; 2016**).

Purely statistical methods use only real unemployment rate to generate NAIRU. Then they divide this indicator into a trend (NAIRU) and a cyclical component (**Richardson et al., 2000**). The underlying assumption of these approaches is that there is no long-term substitution between inflation and unemployment, and that average inflation should fluctuate around NAIRU. In economy there are self-balancing forces, strong enough to draw unemployment back to the trend. According to the above-mentioned authors, the main disadvantage of these methods is the fact that a decomposition based on them depends on differing and sometimes very improbable assumptions (regarding the way of trend estimation modelling and its relation to the whole component). Furthermore, information other than unemployment is not defined well. Most of the filters also lack accuracy of estimates at the end of the sample data. On the contrary, a great advantage of this group of methods is that it applies easily and is not demanding regarding

data. This relates to Baxter-King filters and especially the HP filter that was in the aforementioned previous research ranked among the most sensitive methods defining development of the labour market in the NAIRU values.

In the case of the **Hodrick-Prescott filter**[1]**,** the λ parameter of 1 600 will be applied to the presented analysis. This parameter is generally used for quarterly data analyses.

The reduced form approach was created as a compromise between the two approaches described above. Compared to structural and purely statistical methods, filtering methods of the reduced form have a number of advantages (**Richardson et al., 2000**) as they make the NAIRU estimation in a direct connection with inflation. Since the used PC can be specified differently, it is possible to get an estimate of a well-defined concept. According to authors, shortcomings of these filtering methods include for example the fact that NAIRU estimate indicators are based on the reduced form equation, which does not allow to identify their basic structural relations. This fact increases the difficulty of NAIRU extrapolation in cases when the estimated PC includes only temporary supply shocks. There should also be a stable and well-specified relationship between inflation and unemployment. NAIRU estimates are very likely to depend on specifications of the PC.

Although this group of methods has many negatives, in filtration methods of the Break model (**Fabiani and Mestre, 2000**), Model consistent solution (**Basistha and Nelson, 2003**), Kalman filter (**Richardson et al., 2000**) and Stochastic trend (**Fabiani a Mestre, 2001**) inside the PC reduced form system authors see a significant contribution to improvement of the NAIRU estimate quality across the OECD countries. In terms of the former socialist countries the best results in our previous research were provided by the Kalman filter and the Stochastic trend.

[1] According to **Boone** (2000) a simple HP filter acquires unobservable variables by solving the following minimization problem:

Minimization $\sum (y_t - y_t^*)^2 + \lambda_1 (\Delta\Delta y_t^*)^2,$ (1)

where y is the observed variable, y^* is the unobserved variable and λ_1 is the given parameter indicating smoothness of the unobservable variable.

According to the author the HP filter distinguishes between long-term components of the variable and short-term cyclical fluctuations. y^* represents the trend of the variable y, $y - y^*$ are cyclical fluctuations and $\Delta\Delta y^*$ is the change in the trend line growth rate. The filtered line represents the rolling mean of the observed line. λ_1 influences the balance between smoothness of the trend and the size of cyclical fluctuations.

For better understanding of the role of the parameter λ_1, the author rewrites the minimization problem as follows:

Minimization $\sum \frac{1}{\sigma_0^2}(y_t - y_t^*)^2 + \frac{1}{\sigma_1^2}(\Delta\Delta y_t^*)^2,$ (2)

where σ_0^2 the variance of the cyclical component $\{y - y^*\}$, σ_1^2 is the variance of the trend component growth rate and $\lambda_1 = \frac{\sigma_0^2}{\sigma_1^2}$. The author declares σ_0^2 larger than σ_1^2 causes larger λ_1 and smoother filtered line.

The Kalman filter[2] is considered to be an appropriate form of resolving the probability function of unobserved component models, as **Richardson et al.** (2000) see it. Despite the fact that NAIRU is constant in the basic form, the present analysis assumes its variability over time. **Fabiani and Mestre** (2000) extend the basic inflation equation model of the NAIRU variability law assumption which allows NAIRU to move quite closely around the real unemployment rate; NAIRU is a so-called random walk. In the present analysis NAIRU estimated by the Kalman filter is specified as a random walk in response to shocks. The form of equations describe the stationary state. The τ parameter represents any value that reflects the time varying NAIRU. Again, in literature we do not use the preferred τ value of 0.2 which allows small oscillations in NAIRU estimates, thus preventing large jumps in the estimated NAIRU development. Since the analysis seeks to ensure sufficiently smooth passages between individual stages of NAIRU development in a transition economy and at a time of deep and prolonged recession, based on the results of our previous research we gave preference to the smoothing value of 0.6.

By using the **Stochastic trend**[3] we want to improve the explanatory power of the NAIRU estimate and to enhance its credibility for economic policy-makers. To optimize credibility of

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[2] Authors extend the basic model of time varying NAIRU of a reduced PC form according to the equation (3) as follows:

$$A(L)\Delta p_t = -\theta(L)(u_t - u^*_t) + \gamma' z_t + e_t, \quad (3)$$

where Δp is inflation, $u - u^*$ is the unemployment gap and z represents other variables (supply side factors).

Extension by the wage-price PC according to the equation (4) looks as follows:

$$A(L)\Delta w_t = B(L)\Delta p_t + C(L)\Delta q_t - \theta(L)(u_t - u^*_t) + \gamma' z_t + e_t, \quad (4)$$

where q is productivity and z are other variables (demand side factors).

In conclusion the authors make u^* division. Because of the variability of the NAIRU law they use the process of simple and general random walk:

$$u_t^* = u^*_{t-1} + \eta_t. \quad (5)$$

[3] The system consists of the following 7 equations:

$$\Delta\pi_t = \alpha + a(L)\Delta\pi_{t-1} + \rho(L)(u_{t-1} - u^*_{t-1}) + b(L)z_t + \varepsilon_t^{\pi} \quad (6)$$

$$y_t - y_t^* = \phi(L)(u_{t-1} - u^*_{t-1}) + \varepsilon_t^{yc} \quad (7)$$

In the case of potential output and NAIRU they are expected to follow the following locally linear trend model:

h

$$y_t^* = y^*_{t-1} + \beta_{t-1} + \varepsilon_t^{y*} \quad (8)$$

$$u_t^* = u^*_{t-1} + \xi_{t-1} + \varepsilon_t^{u*} \quad (9)$$

where the two stochastic trends β and ξ are defined as:

$$\beta_t = \beta_{t-1} + \varepsilon_t^{\beta} \quad (10)$$

$$\xi_t = \xi_{t-1} + \varepsilon_t^{\xi} \quad (11)$$

The unemployed gap is modelled as an autoagressive process:

estimates of the results, **Fabiani and Mestre** (2001) developed a series of motion laws that lead to estimation of NAIRU independent of past changes in the inflation rate. Authors think that NAIRU follows the process of random walk extended by the variable stochastic shift called “local linear trend” (the Kalman filter method that is still being used is, inter alia, based on that).

In the basic model specification inflation is measured on the basis of the household consumption deflator. The state of aggregate demand is specified in terms of the unemployment gap. Causality in Okun's law comes from cyclical fluctuations in unemployment to the GDP output. Variables are defined as follows: π is the inflation rate (second year-on-year difference in the consumption deflator), z is the vector of the supply side variables affecting inflation pressures, u is the unemployment rate, y is the (logarithm of) the output level, u* and y* represent NAIRU and the potential product (natural logarithm).

All error terms (ε) in the equations from (6) to (12) are expected to be independent and equally distributed with the zero absolute value and constant variance as well as mutually uncorrelated. This model is a base for other related models. All relevant parameters –coefficients of the equations (6) to (12) and error terms variance – and the two unobserved variables can be estimated with maximum likelihood.

Most empirical models developed to estimate NAIRU using the Kalman filter lead to the equation specification only regarding NAIRU and do not enable us to connect it with a potential output. In order to scrutinize the degree of sensitivity of the results obtained from the described model we carry out modifications in several different ways. In the zero option, which will be subsequently applied in the empirical part, we leave aside the output and Okun’s law gaps. We specify a model composed of the PC (6) where NAIRU is postulated in the form of a locally linear trend (9) and (11). The unemployment gap is eliminated using a relation (12). It is therefore a partial view on the issue only through the labour market. The unemployment gap is not simultaneously affected by the output gap.

3. Empirical application of methods on the NAIRU concept and the concept of economical cycle from the perspective of the V4 counties labour market

In this section we will estimate development of NAIRU in the terms of the Czech Republic, Slovakia, Hungary and Poland. The reason for including these countries in our research is the continuing similarity in their economic development. These countries have taken similar administrative measures in their transition from centrally planned to market economy, their economies are of similar structure and have a similar degree of openness. For the V4 member countries we will derive the influence of the economic cycle on the labour market and the phase of the cycle. We will verify this by the development of the basic indicators of real economy, i.e. the unemployment rate and the GDP growth. We have also included localization of so called specific periods: transformation of economies, post-recession transformation period, period of the boom phase with extensive positive unemployment gaps, financial and economic recession (also the Great recession), post-recessionary period, respectively the final part of the observed period.

$$u_t - u_t^* = \delta(L)(u_{t-1} - u_{t-1}^*) + \varepsilon_t^{uc} \quad (12)$$

Price development in the V4 countries is represented by the household consumption deflator according to national accounts. Their time series were transformed so that they expressed adaptive expectations formation (annual change in time t - annual change in time t-1). To describe development of the labour market we use the unemployment rate of the individual countries defined by ILO in %. Other explanatory variables are the annual change of the exchange rate of the countries (except Hungary), import prices (only the Czech Republic), Brent oil prices (only Slovakia and Poland) and indirect taxes (only Slovakia). Unemployment rates have been seasonally adjusted by rolling multiplicative average. All time series have been tested by the Augmented Dickey–Fuller test, which confirmed their stationarity.

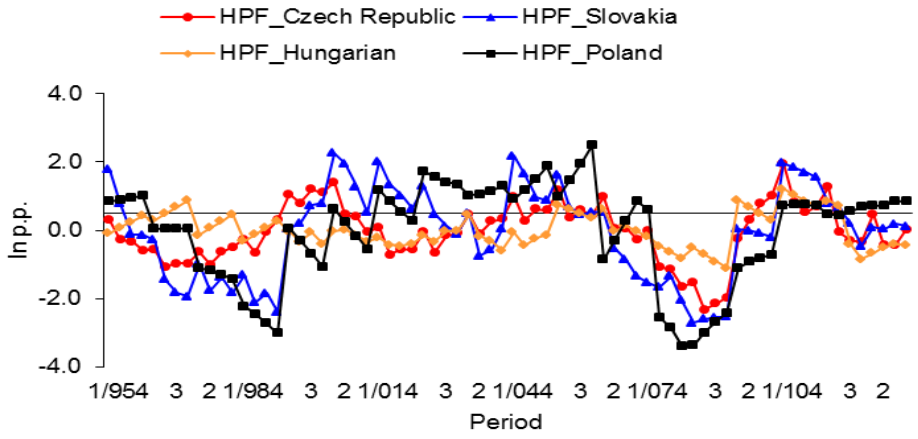
3.1 NAIRU estimated by the HP filter

To estimate the time varying NAIRU we will firstly use the HP filter. Since time series have quarterly frequency, for the analysis we applied an internationally used smoothing parameter λ of 1 600. In the Czech Republic this smoothing has been used for example by **Hájek and Bezděk** (2000, p. 21). Time series of real unemployment will be extended by our own prediction of development in the second half of 2013 and throughout 2014. Thanks to that we will eliminate the main disadvantage of this method, which is a problem at the beginning and at the end of the time series.

According to this method NAIRU in **the Czech Republic** in the period from the 1st quarter of 1995 to the 4th quarter of 2012 ranged from 2.6 to 8.8%. In the observed period the NAIRU values mostly followed the real unemployment rate in close proximity (cf. Graph 1).

Graph 1

Development of the unemployment gap according to the HP filter in individual V4 member countries



Source: Our own calculation based on data from the Czech Statistical Office and the OECD.

A longer-term and larger negative unemployment gap (i.e. the real unemployment rate exceeded the NAIRU) was recorded in the period from the 1st quarter of 1999 to the 1st quarter of 2000, when transformation took place. The actually published unemployment rate in this period annually increased by 2.0 percentage points. This phase was also in line with the evolution of real GDP in constant prices in the previous period. The impact of the Great recession (often generally called financial and economic recession) on the labour market in the Czech Republic can be traced from the 2nd quarter of 2009 and lasted until the 1st quarter of

2011. In the final part of the observed period (from the 3rd quarter of 2011 to the 3rd quarter of 2012) a shallow boom phase was detected.

In **Slovakia** NAIRU estimated by the HP filter ranged from 12.0% to 18.1%. Again, NAIRU fluctuates around the real unemployment rate within a narrow range almost throughout the whole observed period. The effect of transformation of the Slovak economy was reflected on the labour market especially in the period from the 1st quarter of 2000 to the 2nd quarter of 2001. The impact of the Great recession in Slovakia appeared in the 1st quarter of 2009 and continued until the end of 2012. This phase reached its bottom in the 1st quarter of 2010, when the intensity started to diminish up to the value of a negative gap of 0.1 pp in the 4th quarter of 2012. Taking into account the delay of the labour market, the estimated phase of the cycle corresponded with the state of the real economy.

Hungarian NAIRU according to this method ranged from 5.9% to 11.5%. In this state NAIRU copies the real unemployment rate throughout the whole observed period very well – and actually the best of all the observed countries. However, this seemingly obvious consistency became an obstacle for making conclusions of the analysis. The influence of the Great recession began to affect the labour market in the 1st quarter of 2009 and continued until the 2nd quarter of 2011. In the last part of the observed period (from the 3rd quarter of 2011 to the 4th quarter of 2012) the method detected a phase of shallow boom.

In **Poland** the HP filter method estimates NAIRU to range from 8.8% to 18.6%. In this country there were also periods in which the estimated NAIRU copied the real unemployment rate, thus making it impossible to draw clear conclusions from the analysis. The period from 1999 to 2000 is example of a period in which the too close transfer of the labour market development in the NAIRU values and frequent alternation of positive and negative gaps made it difficult to evaluate the phase of the cycle. The method attributed the period from 2001 to 2005 a phase of recession (with a brief interruption in 2003). Negative unemployment gaps associated with transformation of the Polish economy corresponded with real economy numbers only in the first two years. The influence of the Great recession on the labour market thus showed already in 2009 and not in 2010 as the model estimated. By reducing negative gaps to 0.5 pp the model suggested a stagnation phase in 2011, which transformed into a phase of recession again in 2012.

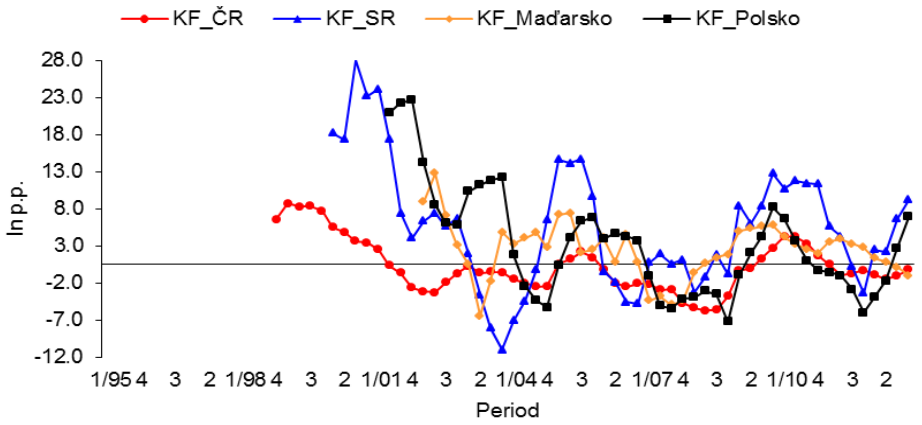
3.2 NAIRU estimated by the Kalman filter

Another method of NAIRU estimation is the **Kalman filter**. According to results of the aforementioned research of the authors, the Kalman filter is the best method for capturing the unstable environment of the labour market and the whole economy. In this context we use an estimated NAIRU smoothing of 0.6. Greater smoothing found that NAIRU estimates showed development of unstable unemployment rate in the environment of transitive economy and in unstable periods (e.g. during transformation of an economy, during the Great recession and the following moderate growth of economy).

In the **Czech Republic** NAIRU values after 0.6 smoothing ranged from **-**1,3 to +11,7%. In the period between the 4th quarter of 1998 and the 3rd quarter of 1999 the estimated NAIRU was negative and then until the 4th quarter of 2000 it was positive. However, the values between 0.4 and 4.3% still did not correspond with the real development of the unemployment rate. Thus the negative and unrealistically low positive NAIRU values were a response of the model incorporating greater smoothing to transformation of the domestic economy.

Graph 2

The unemployment gap development in individual V4 countries according to the Kalman filter



Source: Our own calculation based on data from the Czech Statistical Office, the Czech National Bank and the OECD.

The influence of the Great recession on the labour market in the Czech Republic according to 0.6 smoothing occurred in the period starting with the 3rd quarter of 2009. This phase lasted until the 1st quarter of 2011, and its location corresponded with development of the real economy again. From the 2nd quarter of 2011 to the 2nd quarter of 2012 we can observe acceleration of the positive gap up to 1.5 pp. From the following quarter the boom phase gradually depletes so that in the 4th quarter of 2012 the positive unemployment gap was only 0.2 pp.

In **Slovakia** NAIRU smoothed by 0.6 was in the interval between -9.6 to +28.4%. The negative and low positive values of NAIRU were estimated by the Kalman filter by higher coefficient of smoothing for the period from the 1st quarter of 2000 to the 2nd quarter of 2002. The model therefore showed an unstable period with structural shifts caused by economy transformation at the labour market in Slovakia as well. Unrealistic negative gaps of unemployment corresponded with development of real quantities. In the period from the 1st quarter of 2009 to the end of the observed period, influence of the Great recession on the labour market was discovered. The worst impact on the labour market was in the 4th quarter of 2009 (the negative gap of unemployment was 12.8 pp) and the smallest impact in the 3rd quarter of 2011 (the negative gap was then only 0.2 pp). However, the situation in the following period worsened again, the gap in the 4th quarter of 2012 grew again up to 9.3 pp.

In **Hungary**, NAIRU smoothed by 0.6 was in the interval between -6.4% to +12.8%. Placement of the negative gaps into first part of the period after including the common delay of labour market development after GDP corresponds with the real economy development. Apart from the impact of economy transformation, the estimated gap of unemployment was also influenced by a change of substitution character between the unemployment rate and the household consumption deflator, which was caused by deviation in the HUF/EUR exchange rate, oil prices and import prices development. The Great recession impact on gap unemployment showed already in 2nd quarter of 2008 and lasted until the 3rd quarter of 2012. This recession had two bottoms, the first one occurred in the 4th quarter of 2009 and the second on in the 2nd quarter of 2011. In the 3rd quarter of 2012, the negative gap was exhausted and therefore continued to the boom phase in the following period.

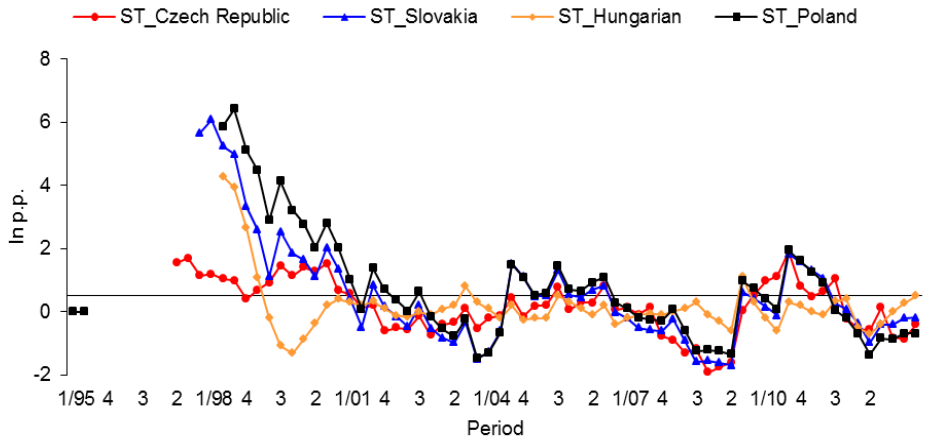
In **Poland**, the NAIRU smoothed by 0.6 was in the interval between -4.5% to +24.3%. In 2001 and 2002, the economic substitution relation between the unemployment rate and the household consumption deflator was disrupted (because of the influence of deviation in the exchange rate and oil prices). The real data were also influenced by the economy transformation. Impact of the Great recession according to both the model and statistical data showed in the period from 2009 to 2012, in 2011 and in the 1st half of 2012 the economy stagnated.

3.3 NAIRU estimated by the Stochastic trend

In the following part we will apply the **Stochastic trend** method to estimate NAIRU variable in time. In the **Czech Republic**, the NAIRU values were according to his method in the observed period between 1.5 to 9.3%.

Graph 3

Unemployment gap development according to the Stochastic trend in V4 countries



Source: Own calculation of data from the Czech Statistical Office, the Czech National Bank and the OECD.

Only this method pointed out on the period from the 4th quarter of 1996 to 1st quarter of 1998 by remarkably large negative unemployment gap (on average 1.3 pp). Real economy development corresponded mostly with the Stochastic method results. The model confirmed conclusions of the HP filter by placing the transformation period of the Czech economy in correspondence with the real economy data into the period from the 1st quarter of 1999 to the 1st quarter of 2000. It is possible to track the impact of the Great recession on the labour market in the Czech Republic in accordance with data as well as with the HP filter from the 2nd quarter of 2009 to the 1st quarter of 2011. Development of the end of the observed period (2nd quarter of 2011 to 4th quarter of 2012) was similar to the Kalman filter results, i.e. the shallow boom phase begun with a delay of one quarter and in the last quarter it was replaced by the stagnation phase, which was the first signal of impact of the new recession on labour market.

In **Slovakia**, the NAIRU values were in the interval from 5.7 to 19.2%. The NAIRU values surrounded the real unemployment rate more tightly than the HP filter values and of course more tightly than the Kalman filter values. The Stochastic trend estimated the period from the 1st quarter of 1999 to the 1st half of 2001 to be the economy transformation period. This period also corresponded with the real data development. Only the Stochastic trend pointed out punctually the impact of transformation on the labour market (the Kalman and the HP filter were up to one year late). The Great recession impact on the Slovakian labour market is from the

2009. This period lasts only to the 2nd quarter of 2011 and from the following period it estimates positive unemployment gap and shallow conjuncture period, which does not correspond with the real data development.

In **Hungary**, the NAIRU values were in the interval from 4.0 to 11.3%. Also here the NAIRU values corresponded with the real unemployment rate less tightly than with the HP filter and more tightly than with the Kalman filter. The economy transformation was estimated for 2000 and for the 1st quarter of 2001. These estimations did not correspond with the real economy development; on the other hand they also did not disrupt the relationship between the unemployment rate and the household consumption deflator. Impact of the Great recession on the labour market occurred in 2009, 2010 and in the first half of 2011, which was formerly estimated by the HP filter and in correspondence with real data. From the 3rd quarter of 2011 to the 3rd quarter of 2012, this method in accordance with the HP filter estimates the positive unemployment gap and shallow conjuncture period, which corresponds with the real data development. It is the only one to estimate the 4th quarter of 2012 to be the recession phase, which also corresponds with the real data.

In **Poland**, the NAIRU values were in the interval from 5.9 to 18.8%. The NAIRU values also fluctuated around the real unemployment rate, less tightly than the HP filter and more tightly than the Kalman filter. While this method estimates the transformation period from 1999 to 2001 (in accordance with the data), the HP filter estimates it from 2001 to 2005 (2004 and 2005 not confirmed by real data) and the Kalman filter estimates it from the 2nd quarter of 2001 to 2004 (the second half of the interval does not correspond with the real data development). The impact of Great recession on the Polish labour market occurred in 2009 and 2010 (the HP filter estimated 2010, the Kalman filter both years), which corresponded with statistics. 2011 and 2012 were the years of boom phase in economy (the HP filter estimated stagnation in 2011 and recession in 2012; the Kalman filter estimated stagnation in 2011 and in the 1st half and recession in the 2nd half of 2012), which did not correspond with the real data that showed stagnation in 2011 and recession in 2012.

Conclusion

The first aim of this paper was to apply selected methods of NAIRU estimation on V4 member states. For this purpose, we applied the HP filter, the Kalman filter and the Stochastic trend methods. The analysis main point was the estimation of NAIRU variable in time because it describes most precisely the development of countries undergoing transformation and the development of financial, economy and debt crisis. This set of models should above all increase the explanatory value of economy processes estimations and increase credibility of obtained results for economic policy decision-making. The estimated NAIRU values were then used to calculate the unemployment gap which was then used to observe the economic cycle on the labour market. The next step was to compare the economic cycle phases with development of the basic indicators of real economy. In the final part of the analysis, we located unstable periods on the labour market in selected V4 countries. The main reason for them to occur was economy transformation during transition between two political and economic systems and impact of the Great recession. In the following period, the development after the Great recession was diverse.

At first, the analysis focused on **comparison of obtained NAIRU values,** first according to the used method within each country and then also according to contrasting individual countries. In **Slovakia, Hungary and Poland**, the NAIRU values according to the Stochastic trend corresponded with the real unemployment rate less closely than with the HP filter and more closely than with the Kalman filter. The situation in the **Czech Republic** was different; the Stochastic trend method corresponded with the real unemployment rate most closely of all

applied methods. In this context it should also be mentioned that HP estimations closely corresponding with the real unemployment rate proved to be an obstacle in drawing unambiguous conclusions from the analysis. In such periods, the unemployment gaps were almost zero and the estimated phases lasted only for short time.

Another thing to emphasize is the fact that **the Stochastic trend method in the Czech Republic was the only one to point out the remarkable negative unemployment gap between the 4th quarter of 1996 and the 1st quarter of 1998.** The HP filter also paid attention to this period but its estimation of the shallow boom phase did not correspond with development of the real data, which occurred in connection with weaknesses of the method it the beginning and the end of time series. In **Slovakia, Hungary and Poland**, this method estimated a remarkable negative unemployment gap in 1997 and 1998, which did not correspond with the real data development.

The following part thoroughly analysed **the ability of the methods to estimate the influence of V4 countries economy transformation on the labour market in accordance with the real economy data development.** The Stochastic trend estimated the transformation period of the **Czech** economy, in correspondence with HP filter, from the 1st quarter of 1999 to the 1st quarter of 2000. The Kalman filter estimates this period to begin already in the 4th quarter of 1998 and to end as late as in the 4th quarter of 2000, which does not correspond with the real data. The transformation period of the **Slovak** economy was estimated from the 1st quarter of 1999 to the 1st half of 2001 (four quarters earlier the the estimates of the HP filter and the Kalman filter). The transformation period in **Hungary** was estimated from 2000 to the 1st quarter of 2001 which did not correspond with the real economy development. The Kalman filter did not provide any data for this period and the gaps estimated by the HP filter had low explanatory value. In **Poland** the Stochastic trend estimated the negative unemployment gaps from 1999 to 2001. The HP filter estimated transformation phase from 2001 to 2005 (2004 and 2005 were not confirmed by real data) and the Kalman filter estimates it cca two years in advance. In **Czech, Slovak, Hungarian and Polish economy**, the Kalman filter estimated negative and unrealistically low NAIRU values. Another reason for unrealistically large unemployment gaps was fluctuation in oil prices, exchange rate, import prices and regulated prices, which disrupted the relationship between unemployment and the household consumption deflator.

Another thing proved by all three method was **the period of large positive unemployment gaps in V4 member states.** In the **Czech Republic**, the estimation of the boom phase of the Stochastic trend from the 4th quarter of 2007 to the 4th quarter of 2008 corresponds with the Kalman filter estimation. The HP filter estimates this phase to begin already in the 2nd quarter. In **Slovakia** the positive gap and the boom phase were by the Stochastic trend and the Kalman filter estimated for 2008. HP filter is the only one to punctually record impact of boom on the labour market. In **Poland** the Stochastic trend estimated recession from 2004 to 2006 which did not correspond with the real data. The boom phase continued till the end of 2008. The reason for large positive gaps (cca 5 pp) in the Czech Republic was the inability of the method to appropriately reflect the recent significant improvement in the labour market in the NAIRU values.

The last fact that was reflected by all methods was the Great recession in the V4 countries. According to the Stochastic trend and the HP filter estimations, the recession influenced the **Czech** labour market one quarter earlier than was estimated by the Kalman filter. In **Slovakia** this phenomenon influenced the labour market from the 1st quarter of 2009. Unlike the HP filter and the Kalman filter estimations, this period lasted only until the 2nd quarter of 2011. In **Hungary** the recession's impact on the labour market occurred, according to the Stochastic trend and the HP filter, in 2009, 2010 and in the 1st half of 2011. The Kalman filter

estimated if from the 2nd quarter of 2008 to the 3rd quarter of 2012. In **Poland**, the Stochastic trend and the Kalman filter estimated the impact of recession on labour market in 2009 and 2010 (the HP filter confirmed on the 2010).

In terms of the various methods, evaluation of the last part observed period in the V4 states seems ambiguous. In the **Czech Republic** the development from the 2nd quarter of 2011 to the 4th quarter of 2012 estimated by the Stochastic trend, i.e. the shallow boom phase with depletion in the last quarter corresponded with the Kalman filter. According to the HP filter, the phase started one quarter later. In **Slovakia** the Stochastic trend model estimates the positive unemployment gap from the 3rd quarter of 2011 which does not correspond with the real data, therefore the HP filter and the Kalman filter proved to be more suitable to estimate NAIRU in unstable environment. In **Hungary** the Stochastic trend and the HP filter estimate the shallow boom phase already from the 3rd quarter of 2011 to the 3rd quarter of 2012. In Poland the Stochastic trend estimated a boom phase for 2011 and 2012 which however does not correspond with the real data. The HP filter and the Kalman filter estimated stagnation in 2011 and recession in 2012. Therefore the Stochastic trend method absolutely failed since the other two methods estimated both the phases correctly and the Stochastic trend did not estimate correctly any of them.

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