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Use of the method of the stochastic trend for NAIRU estimation in the Czech Republic and Slovakia at the macro- and meso-levels

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ABSTRACT

The article provides an analysis of the development of NAIRU and the economic cycle in the labour market at the level of the economy and in selected sectors in the Czech Republic and Slovakia. The analysis focuses on estimation of the time-varying NAIRU with the use of the method of the stochastic trend. The difference between the estimated NAIRU values and the real unemployment rates is used for characterisation of the economic cycle in the labour market. The estimated phases of the cycle are compared with the development of the basic real economy indicators. Unstable periods on the labour market in the economy and in selected sectors of the two countries are localised. The identified leading indicators are used for prediction of the development in the following period.

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1. Introduction

To describe the economic reality, macroeconomic theory and economic policy use categories such as growth, inflation, unemployment, etc. (Stock & Vogler-Ludwig, 2010). Attention should therefore be paid to concepts such as the Phillips curve (hereinafter PC), NAIRU (non-accelerating inflation rate of unemployment), or Okun's law, which help us understand the relationships among growth, inflation, and unemployment. So far, practical applicability of these concepts is limited. Nevertheless, they help us understand the relationships among macroeconomic categories. Some of the concepts of NAIRU can also be used for economic policy recommendations.

The creation of meso-economics in the 1930s has also been very beneficial. For example, Andersson (2003) thinks that meso-economics enables us to understand individual parts of the economic aggregate and relations among them. Preston's (1984) opinion was that conclusions provided by meso-economics would clarify driving forces in the economy.

The aim of this article is to demonstrate the importance of doing research on the level of sectors, as they reflect the impending recession earlier than the economy as a whole, and to

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compare the results of the method of the stochastic trend with other previously published methods of NAIRU estimation (Kadeřábková & Jašová, 2012). The fact that we widened the range of methods used should contribute to an improvement of the explanatory power and credibility of unobservable variables for setting the economic policy. We acquired an overview of the development of the economic cycle on the labour market by subtracting NAIRU values estimated by the model from the actually published unemployment rate. To verify the estimated phases of the economic cycle on the labour market we compared the calculated unemployment gaps with the development of the real unemployment rate and the added value in relevant periods. At the same time, we were interested in the transformation period of the economy during the transition between two politico-economic systems, as well as the period of extensive positive gaps in unemployment between 2007 and 2008, the period of the last recession and the period immediately following the last recession. In addition, we mapped and quantified the advance in development of some of the analysed countries and in the development of some of the 'meso' categories. By doing so we obtained leading indicators that can be used to predict development in the following period.

The paper is divided into the following parts. The first part gives an overview of the development of the conceptual framework of substitution between inflation and unemployment. The second part is focused on methods for NAIRU estimation. In the third part there is an application of the stochastic trend method to estimate NAIRU to the conditions of the economy and selected sections of the Czech Republic (hereinafter CR) and Slovakia. Further on, we compare these results with the conclusions of previous research carried out by applying the Hodrick–Prescott filter (the HP filter) and the Kalman filter. A summary of the results of the analysis and their comparison with the previous research based on other methods will be presented in the Conclusion.

2. Contribution of individual authors to substitution between inflation and unemployment

The issue of substitution between inflation and unemployment has been paid a lot of attention in world literature during the last 250 years. Humphrey (1985) gives an overview of the contributions of individual authors to the PC concept, including the contribution of Phillips himself. Based on statistical results, Phillips (1958) came to the conclusion that the rate of change in money wages can be explained by the level of unemployment and the unemployment change rate. Samuelson and Solow (1960), who formulated the relation between the price inflation rate and the unemployment rate, considered the relation to be unstable over a longer period of time. Phelps (1967) saw the substitutional relation between unemployment and inflation as dynamic. Friedman (1968) pointed out the fact that at every given moment the level of unemployment was consistent with the balance in the structure of real wages rates. He thought that between inflation and unemployment there was only a temporary substitution. Modigliani and Papademos (1975) considered the non-inflationary rate of unemployment, or NIRU, to be a rate at which decrease in inflation can be expected. Dumlao (2014) was interested in mapping the historical excursus into development of interpretation of the relation between price development and the unemployment rate since the year 1958. In our article we apply the concept of NAIRU because of its simpler empirical estimation. Tobin (1997) is considered to be the author of NAIRU. According to him, NAIRU is a result of macroeconomic balancing of pressures on

the growth of inflation growth and pressures on the decline of inflation. Akerlof, Dickens, and Perry (1996) have contributed to expansion of the concept. They consider NAIRU to represent balancing of unemployment by real wages. Ball and Moffitt (2001) included the difference between the growth of work productivity and the average real wage in the prior period into the concept of NAIRU.

Authors such as Richardson et al. (2000) build substitution between unemployment and inflation on what is known as the natural unemployment rate. This unemployment rate allows inflation to be stable (Estrada, Hernando, & López-Salido, 2000). The authors call the concept non-accelerating inflation rate of unemployment, or NAIRU. They subtract the real unemployment rate from NAIRU and use the resulting gap to create recommendations for the economic policy.

Analysis of NAIRU at the level of sectors was among the interests of, e.g., Gordon (1996), who pointed out the difference in development in individual sectors within the whole economy. Maro (2002) in his research revealed that there was an impact of sectoral changes on the overall unemployment level. Eagly (1965) also carried out a sectoral analysis of the PC. It was part of his research on the relation between changes of wages in industrial sectors and changes of the index of bargaining power on the level of unemployment of civilians. Neumark (1993) studied the influence of sectors on shifts of the PC at the national and sectoral level. Leith and Malley (2003) statistically confirmed the difference in the development of individual sectors and by doing that they revealed that they performed a different reaction on the monetary policy. Rao (2001) mentions substitution between the increase in wages and hiring secondary (temporary) employees. Lester (2001) found that if unemployment is on the rise, negotiated wages of efficient workers grow. After extension of his Scandinavian model of small economies by the PC equation, Brown (1988) found that demand incentives increased the difference between inflation and productivity of protected and export sectors. An analysis on the meso-level for the CR was carried out in articles by Kadeřábková and Jašová (2011) and Jašová and Kadeřábková (2012).

Boone (2000) sees NAIRU as a trend value and an unobservable variable, which can be determined by special methods designed for this purpose. NAIRU estimates are accompanied by a number of uncertainties and authors therefore regard NAIRU as little applicable for economic policy decision-making (Estrada et al., 2000). McAdam and McMorrow (1999) and other economists think that the NAIRU concept can find application in the field of economic theory. As for the sphere of economic policy, the application relates to assessing adaptability of the labour market in various economies, labour market functioning, and implementation of essential measures in individual countries.

3. Review of the methods for estimation of the time-variable NAIRU

To estimate NAIRU it is necessary to apply econometric methods, as NAIRU is an unobservable variable. According to Pošta (2008), to choose a method for empirical estimation, it is important to distinguish the natural unemployment rate from NAIRU. For estimation of the natural unemployment rate, structural models are used. Apart from that, NAIRU is also estimated by purely statistical methods. Authors (Richardson et al., 2000) define purely statistical methods, which for example include the HP filter. This method divides the unemployment rate into two components, namely the trend (NAIRU) and the cyclical component. The disadvantage of this method is the limitless selection of the coefficient

for smoothing the NAIRU values' variability. Another disadvantage is that the HP filter method includes only the unemployment development rate, which leads to an incomplete definition of the obtained indicator. The authors talk about a group of methods called the Reduced Approach Form, which is represented by the Kalman filter and the stochastic trend. As for the Kalman filter, to extract NAIRU, behavioural equations are used. The values of NAIRU also reflect the development of inflation and statistically significant explanatory variables. The progress of NAIRU is modelled as a random walk in response to shocks. As this method cannot detect fundamental structural links, it sometimes raises doubts. For example Botric′ (2012) used the Kalman filter to estimate the time-varying NAIRU in Croatia. The author claims that the dynamics of the estimated NAIRU showed there was substantial structural mismatch in the whole economy. She also confirms that the NAIRU estimate is useful for economic policy decision-making. Botric′ (2008) also presents an overview of authors who study the macroeconomic theory and carry out empirical studies defining the NAIRU indicator. Claar (2005) sees NAIRU and the natural unemployment rate as two terms that are not interchangeable. According to a broad consensus, NAIRU represents an empirical macroeconomic relation. There is little agreement between NAIRU and the natural unemployment rate. The author defines the natural unemployment rate as an unemployment rate corresponding to the balance on the labour market. He used the Kalman filter for the estimate.

The stochastic trend is a method by which we expand the number of the previously used methods to estimate the time-variable NAIRU. The aim of this modification is to broaden our view of the issue, to improve the explanatory power, and enhance the credibility of the NAIRU estimate for economic policy-makers. To make sure that their results were plausible, Fabiani and Mestre (2001) have come up with a way of estimating NAIRU independent of past changes in the inflation rate and used a system approach. According to the authors, NAIRU follows a random walk process extended by the variable stochastic trend, which is called the 'local linear trend'. The advantage of this system is that by using structural information it is possible to estimate all relevant parameters of the system. Standard methods based on individual cyclical indicators (the unemployment gap) and on the assumption of the change of NAIRU as a pure random walk are not able to identify the variability of the process. Furthermore, modelling of short-term fluctuations of individual cyclical indicators leads to the fact that determination of all relevant parameters is estimated with higher uncertainty than if more than one indicator was used.

As for the Czech Republic and its conditions, Izák (2000), for example, characterised the labour market using the classic wage PC. Hájek and Bezděk (2000) used the HP filter for the estimate of the natural unemployment rate. Fukač (2003) estimated the time-varying NAIRU by an expanded Kalman filter with a backward smoothing filter. The aim of the study by Bezděk, Dybczak, and Krejdl (2003) was to estimate the economic cycle using the HP filter, which they consider to be easy to apply and not demanding for data. Furthermore, the authors appreciate the option to use the λ smoothing parameter. Because of the fact that structural breaks are defined by both the previous and the following observation, the authors used λ 480 for smoothing of the quarterly data, instead of the commonly used 1 600. Beneš and N′Diaye (2004) think that the modern standard of the potential product and NAIRU are filtering techniques. The simplest option is the univariate filter and therefore also the HP filter. Pavelka (2005) came to the conclusion that the PC existed in the conditions of the CR based on the decrease of the inflation rate in 2004 compared to 1993. Hurník and Navrátil

(2005) estimate the NAIRU variables by the maximum likelihood method, which links the inflation equation with the equation describing the explicit path of NAIRU. To estimate NAIRU they apply the technique of backward recursion, which provides a conditional estimate. The advantage is that it eliminates the arbitrary selection of the λ coefficient in the HP filter. On the other hand, the authors see a disadvantage in the fact that the estimate is dependent on the assumption of normal distribution of error elements.

As for Slovakia, to estimate NAIRU, Gylánik and Huček (2009) used statistical methods (HP filter and Band-Pass filter) and methods based on a combination of statistical methods and economical information (univariate HP filter and Kalman filter), as well as econometric models that link unemployment, inflation, and the production gap (wage and price model). According to the authors, the deviation of unemployment from NAIRU provides us with information about periods of imbalance on the labour market. To estimate the production gap in Slovakia, Šrámková, Kobilicová, and Krajčír (2010) use the multivariate Kalman filter, as it ensures a flexible environment for modelling and simultaneous interconnection of the goods market and the labour market. Varga (2013) uses the Kalman filter to estimate NAIRU by the Gordons Triangle model for the Czech Republic, Slovakia, and Hungary. The time-varying NAIRU is described as a latent variable following the random walk and the deviation from the real unemployment influences inflation. Varga expanded the model by inflation expectation, even though it led to a decrease in the statistical significance of the unemployment gap coefficient. Significant substitution was only proved for the CR and Hungary.

4. Development of NAIRU and the business cycle from the perspective of the labour market in the economy and in selected sectors of the Czech Republic and Slovakia

In this part we estimate the development of the time-varying NAIRU in the Czech economy and in selected sectors in the CR and Slovakia only by the system approach of Fabiani and Mestre (2001), which we shortly call the stochastic trend. This method has not yet been applied in the CR and Slovakia by the authors we cite. We use the method of the stochastic trend to verify the validity of Fabiani and Mestre's conclusions in the conditions of the CR and Slovakia. We also apply this method for the analysis on the meso-level. The authors talk about a new fact concerning the link between inflation and demand pressures, which is measured in relation to cyclical changes of unemployment. In this context, their empirical analyses suggested a statistical robustness accompanied by a high level of uncertainty of NAIRU estimates. The obtained NAIRU estimates according to their system are robust, both regarding the resulting NAIRU and its variability in the course of time. The system approach of the authors provided information about the behaviour of unemployment and inflation in Europe during the implementation of reforms on the labour market.

The estimates obtained by the method of the stochastic trend will then be compared with previously published conclusions of NAIRU estimates and the unemployment gap based on the HP filter and the Kalman filter. Several methods of NAIRU estimation together have never been used in the environment of the Czech economy. As for Slovakia, there is only one study that takes into account several methods of NAIRU estimation. Its authors are Gylánik and Huček (2009). In countries of the euro area, Fabiani and Mestre (2001) estimated NAIRU using what is called a system approach, based on the Kalman filter and

the HP filter. Richardson et al. (2000) use the Kalman filter and the HP technique of multivariate filter to estimate NAIRU in 21 countries of the OECD. By comparing different methods of measuring we can assess the consistency of characteristics of variables and the number of features in common. We verify the estimated values of NAIRU and unemployment gaps by the development of real economy indicators. We also use the comparison of different methods to assess the level of uncertainty of the estimated NAIRU values and the unemployment gaps.

4.1. Specification of the method of stochastic trend and defining initial time series for NAIRU in the CR and Slovakia

In this paper we use the method of stochastic trend derived from the system approach of Fabiani and Mestre (2001), which is based on the PC, Okun's law, and a set of equations. The equations define the law of motion of unobservable variables, including a potential output and NAIRU.[1] The Phillips curve connects inflation, aggregate demand, and vector shocks on the supply side of the economy.

Okun's law describes the relation between the gap of the output and the unemployment gap; the direction of the dependency varies according to the sources of shocks that affect the system. In relation to the equations defining the source of motion for unobservable variables, the authors assume that NAIRU and the potential output follow the process of the random walk, which is expanded by the stochastic variable shift (trend). The authors use this 'local linear trend' in the conditions of the euro area because of the irrationality of the assumption about stable (stationary) level of variables. According to preliminary results of analyses, it is necessary to increase the credibility of estimates by the smoothed stochastic trend. The authors use it despite the illusion that unemployment is a variable $I(2)$, as in their opinion it reflects a significant change in the upward direction in a certain point of the way, which then does not repeat.

In the basic specification of the model (see Note 1) the authors measure inflation by the consumption deflator; the state of the aggregate demand is represented by the unemployment gap and the causal link in Okun's law comes from the cyclical fluctuations in unemployment to output. The variable π represents the inflation rate (the first difference of the logarithm of the consumption deflator); z is a vector of variables influencing the supply side that affects inflationary pressures, u is the unemployment rate, y is (a logarithm of) the output level, and $u^{\star}$ and $y^{\star}$ represent NAIRU and the potential product (logarithm).

Within this basic specification, the price development was measured based on the household consumption deflator (in the economy) and the deflator of manufacturing and construction industries (in selected sectors) according to national accounts. The time series was adjusted to reflect the difference between the current inflation and adaptive expectations, which are based on the inflation development in the previous period (Gordon, 1990). The criterion for selection of the household consumption deflator according to national accounts – as opposed to the study by Hurník and Navrátil (2005), who used the consumer price index – was the attempt to cover the widest possible spectrum of price impulses in the economy.

To describe the development in the labour market in the whole NE we use unemployment rates published by the International Labour Organisation (ILO) in percent. Due to the lack of officially published statistics we made our own calculation in percent for the specific unemployment rate in industry and the construction sector in both the countries.

The reason for differentiating between the macro-level and the meso-level, which was not done by the authors we cite, was the fact that we wanted to cover dynamising processes in the economy and to identify the start of the new phase of the cycle in the labour market at the earliest point possible. As for the CR, we used a method that had already been published in a work by Kadeřábková and Jašová (2011). For Slovakia we used the same calculation algorithm as in the conditions of the CR and we based it on the time series 'The unemployed according to the economic activity of the last employment (according to the Labour force sample survey)' and 'Employment according to the Labour force sample survey', published by the Statistical Office of the Slovak Republic (http://slovak.statistics.sk/wps/portal/ext/themes/demography/labour/).

Other explanatory variables in the model for the CR are year-on-year changes of the currency rate towards euro and import prices. The exchange rate was statistically important only in relation to the economy and the construction sector with a delay. The exchange rate was statistically significant only for the analysis of the economy with a delay. In the conditions of Slovakia, statistical significance was proved for exchange rate variables (only at the level of the economy with a delay), import prices (only in the construction sector without a delay), and for Brent crude oil (only in industry and in the construction sector without delay). On 1 January 2009, the euro became the official currency of Slovakia. From this day until the end of the analysed time period, a firmly fixed rate of the Slovak crown towards euro was applied – 30.1260 SKK/EUR (Directorate General Communications, 2008).

A sample of the overview of parameters, *P*-values, selected characteristics of models and cyclical fluctuations for the analysis is provided in Table A1 of the Appendix. Unemployment rates were seasonally adjusted by the multiplicative rolling average. The analysis in the CR and in Slovakia covers the time period from the 1st quarter of 1995 to the 4th quarter of 2012. The sources of data including internet sources are listed in the References. The models were estimated with the use of the econometric programme EViews (EViews, 1998).

4.2. NAIRU estimated by the stochastic trend for the data of the CR

According to this method, the NAIRU values in the observed period in the economy were in the interval from 1.5 to 9.3%. The NAIRU values relatively closely copied the real unemployment rate. Unemployment gaps in the case of the stochastic trend ranged from –1.9 to +1.9 pp.

This method drew attention to the negative unemployment gap (which had on average 1.3 pp) between the 4th quarter of 1996 and the 1st quarter of 1998. The real economy development overlaps with the conclusions of the stochastic trend method, as the unemployment rate in this period grew annually by 1.1 pp and the GDP in the period from the 1st quarter of 1996 to the 2nd quarter of 1997 decreased the annual growth rate to 2.8% (in 1995 +6.0%). In compliance with the data of the real economy, the model placed the period of transformation of the Czech economy in the term from the 1st quarter of 1999 to the 1st quarter of 2000 (see Figure 1). The estimate of the positive gap and the phase of economic boom in the period from the 4th quarter of 2007 to the 4th quarter of 2008, using the stochastic trend, overlaps with development of the unemployment rate and GDP. The influence of recession on the labour market in the CR can be traced in accordance with the data from the 2nd quarter of 2009 to the 1st quarter of 2011. Development in the final part of the observed period (2nd quarter of 2011 to the 4th quarter of 2012) was similar to

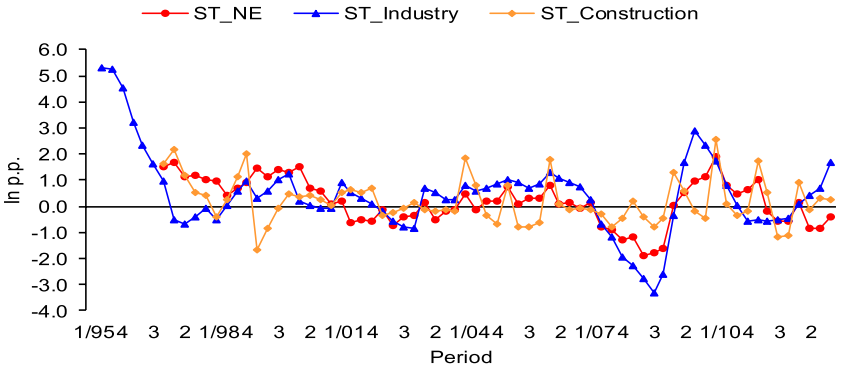

Figure 1. Development of unemployment gaps in the Czech economy and in selected sectors in the CR according to the stochastic trend. Source: Own calculation based on data from the Ministry of Labour and Social Affairs, the Czech Statistical Office, and the Czech National Bank.

the phase of shallow boom with its exhaustion in the last quarter. This model estimate was compliant with the data development.

In industry the NAIRU values were in the interval from 5.3 to 12.6%. The stochastic trend markets the period of transformation of the economy as the period from the 3rd quarter of 1998 to the 4th quarter of 2001 (see Figure 1). Defining this period was in compliance with the real data development (the specific unemployment rate, the added value). This method places the beginning of the following positive gap and the phase of economic boom in the 2nd quarter of 2007. The end of this period was in the 1st quarter of 2009, which corresponded with the data of the real economy. The influence of the recession started to be apparent in the 2nd quarter of 2009 and lasted until the 2nd quarter of 2010. Marking out the recession according to the stochastic trend corresponds with the real data development as well. In the period from the 4th quarter of 2010 to the 4th quarter of 2011 we localised a phase of economic boom with an average positive gap of 0.5 pp (the specific unemployment rate decreased annually by 1.8 pp and the added value increased annually by 12.7%). According to the model, in the period following after the recession (year 2012), the labour market was in a recession again with the negative gap of unemployment of 0.7 pp. The specific rate of unemployment decreased annually only by 0.2 pp and the added value decreased by 1.4%.

As for the construction industry, the NAIRU values were in the interval between 3.7 and 12.0%. The method marked out the period of transformation of the economy in the period from the 1st quarter of 2000 to the 4th quarter of 2001 (see Figure 1). Estimates of the stochastic trend corresponded with the development of the economy. Positive gaps of approximately 0.3 pp were found in the period from the 3rd quarter of 2006 to the 4th quarter of 2008. Such definition of the phase of the economic boom on the labour market is in compliance with the real economy development. In the construction sector, recession showed from the 1st quarter of 2009 to the 4th quarter of 2012.

When considering the stochastic trend, it is necessary to highlight the fact that conclusions in this period must be only regarded as indicative. That is because eventually it became clear that the movement of NAIRU that was close to the real specific unemployment rate was disadvantageous. What happened was that apart from low values of the calculated

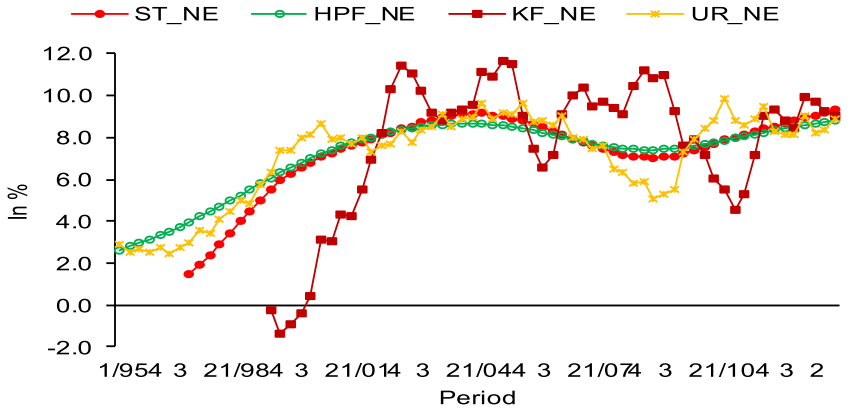

Figure 2. Development of the real unemployment rate and NAIRU in the Czech economy according to the HP filter, the Kalman filter, and the stochastic trend. Source: Own calculation based on data from the Ministry of Labour and Social Affairs, the Czech Statistical Office, and the Czech National Bank.

unemployment gap there also was a frequent switching of the cycle phases. Nevertheless, even this period corresponded with the development of the real economy, as the specific unemployment rate grew annually by 0.8 pp and the added value decreased by 1.2%.

According to the results of our previous analyses, the close movement of NAIRU around the real unemployment rate in the economy (see Figure 2) and in both the sectors was also proved by the HP filter method. Based on the Kalman filter, the NAIRU values diverged from the real unemployment rate quite significantly. The phase of transformation of the Czech economy as estimated by the HP filter showed in the construction sector three years in advance of the whole NE development and with the delay of three quarters after the industry development. The Kalman filter responded to the process of transformation in both the sectors of the Czech economy by negative and unrealistically low positive values of NAIRU. According to the HP filter, the influence of recession on the construction industry on the labour market showed in the same period as in the whole NE. According to the Kalman filter, the beginning of influence of this phase corresponded with the development in the economy but it lagged behind the development of industry. Using the HP filter, the phase of the following shallow boom was detected only in the economy and in the industry sector. According to the Kalman filter, this phase in the economy finished at the end of 2012, while in industry it was already over in 2011.

4.3. NAIRU estimated by the stochastic trend on the data of the Slovak Republic

In the whole economy of Slovakia the NAIRU values were in the interval from 5.7% to 19.2%. The method used pointed out the period between 1997 and 1998. The stochastic trend marked out the period of transformation of the economy as the period starting in the 1st quarter of 1999 and lasting until the 1st half of 2001 (see Figure 3). This period was also in compliance with the real data development. The method places the estimate of the following positive gap and the phase of economic boom to the period of 2008. The influence of the recession on the Slovak labour market also started to be apparent in the 1st quarter of 2009. This period lasted only until the 2nd quarter of 2011. From the following quarter

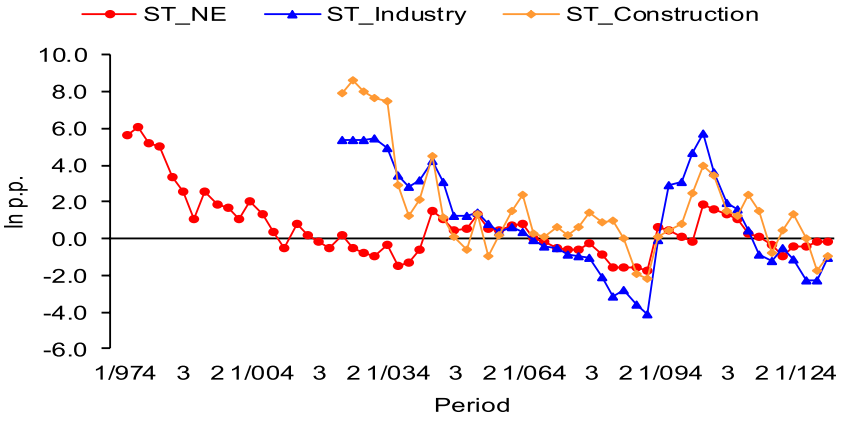

Figure 3. Development of the unemployment gaps in the Slovak economy and in selected sectors in Slovakia according to the stochastic trend. Source: Own calculation based on the data of the Statistical Office of the Slovak Republic and OECD.

there is already an estimate of a positive gap of unemployment and a period of shallow boom, which is in contradiction with the development of real data.

The values of NAIRU in industry ranged in the interval from 10.8% to 17.4%. According to this method, the period of transformation of the economy lasted from the 1st quarter of 2002 to the 1st quarter of 2006 (see Figure 3). Nevertheless, estimates of the stochastic trend were not accompanied by an adequate development of the real economy. Small positive gaps were detected in the period from the 1st quarter of 2006 to the 1st quarter of 2009. According to the stochastic trend, the phase of boom on the labour market corresponds with the real economy development. Recession on the labour market in the industry sector became apparent in the period from the 2nd quarter of 2009 to the 1st quarter of 2011. In the period starting from the 2nd quarter of 2011 and lasting until the end of the observed period there was a phase of boom localised in industry.

According to the method of stochastic trend, the NAIRU values in the construction sector ranged in the interval from 7.0% to 19.0%. This method assessed the period of transformation of the economy as the period lasting from the 2nd quarter of 2002 to the 2nd quarter of 2004 (see Figure 3). However, estimates of the stochastic trend did not correspond with the development of the real economy. Small positive gaps were detected in the period from the 3rd quarter of 2004 to the 3rd quarter of 2005. According to the stochastic trend, the phase of economic boom on the labour market is in compliance with the real economy development. In the construction sector, recession on the labour market became apparent in the period starting from the 2nd quarter of 2009 and lasting until the 1st quarter of 2012, which corresponded with the development of the unemployment rate and the added value. According to the stochastic trend, in the last three quarters the labour market was already in the phase of the economic boom. However, the attempt to confirm this by the real data development failed.

According to the aforementioned HP filter analysis, the estimated NAIRU values in industry ranged around the real specific unemployment rate in a greater distance than in the economy (see Figure 4) and in the construction sector. Based on the HP filter, the influence of the transformation of the whole Slovak economy showed in advance of both

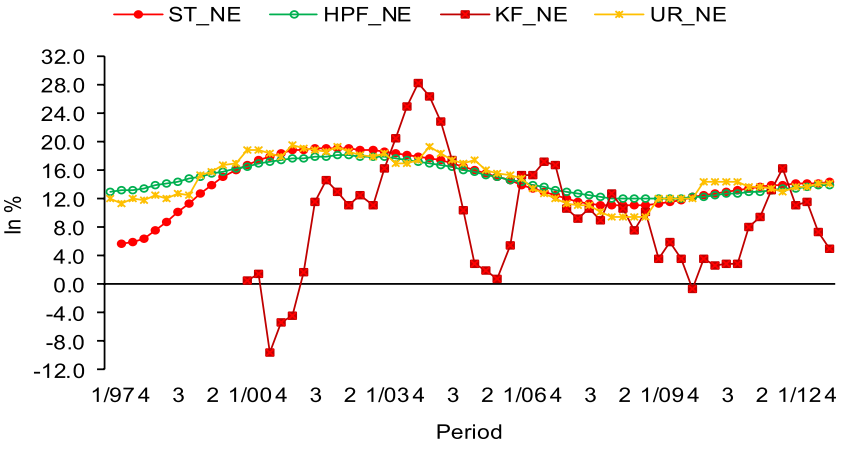

Figure 4. Development of the real unemployment rate and NAIRU in the Slovak economy according to the HP filter, the Kalman filter, and the stochastic trend. Source: Own calculation based on the data of the Statistical Office of the Slovak Republic and OECD.

the selected sectors. The end of the assessed phase was detected at the level of the whole economy and the two selected sectors followed after it. The Kalman filter responded to the phenomenon by negative and low positive values of NAIRU again. In industry this period partly overlapped with the development of construction; it started later and lasted longer than in the economy. According to the HP filter, the influence of recession in industry was shorter than in the construction sector and in the economy. According to the Kalman filter this phase lasted in the economy until the end of the year 2012. In the construction sector it concerned only the 1st half of 2011. Based on the HP filter, the following phase of boom in industry was detected in the whole year 2012, while in construction it concerned only the last two quarters. According to the Kalman filter, in construction this phase ended in the 1st half of 2012 while in industry it was already completed at the end of 2011.

5. Conclusion

The performed analysis provided NAIRU values for the two countries both at the level of the economy and at the level of selected sectors. Based on the stochastic trend, the values of NAIRU ranged from 1.5% to 9.3% in the *Czech economy*, from 5.3% to 12.6% in *industry*, and from 3.7% to 12.0% in the *construction sector*. A comparison of the stochastic trend with the HP filter and the Kalman filter shows that the NAIRU values obtained by the stochastic trend for the *economy* and *industry* copied the real unemployment rate much more closely. In *Slovakia* the stochastic trend generated an interval from 5.7% to 19.2% for the *economy*, an interval from 10.8% to 17% for *industry*, and from 7.0% to 19.0% for the *construction sector*. As for the *construction sector*, the HP filter was the one that copied the real unemployment rate the most closely, followed by the stochastic trend, and then the Kalman filter. In *industry* the NAIRU values according to the stochastic trend corresponded most closely with the real unemployment rate.

Thanks to the analysis it is also possible to assess the ability of the method to capture the influence of transformation of the economy on the labour market in comparison with the

development of the real economy data. In compliance with the real data development the stochastic trend placed the period of transformation of the *Czech economy* in the period from the 1st quarter of 1999 to the 1st quarter of 2000. As for *industry*, the stochastic trend marked the period from the 3rd quarter of 1998 to the 4th quarter of 2001 as the period of transformation of the economy. In relation to *the construction sector* it was between the 1st quarter of 2000 and the 1st quarter of 2001, which was in compliance with the real economy development. In the CR the transformation period started in the industry sector two quarters ahead of the economy and a year ahead of the construction sector. The stochastic trend placed the period of transformation of the Czech economy in accordance with the HP filter, but not with the Kalman filter (the 4th quarter of 1998–the 4th quarter of 2000).

The stochastic trend marked the period from the 1st quarter of 1999 to the 1st half of 2001 as the period of transformation of the *Slovak economy* (which corresponded with the data). As for *the construction sector*, due to the transformation the recession phase began only in the period of 2001 and the end of this phase was placed into the year 2004. However, estimates of the model did not correspond with the real economy development. According to the stochastic trend method, in *industry* the period of the transformation of the economy lasted from the 1st quarter of 2002 to the 1st quarter of 2006, which was not in compliance with the real economy data. According to this method, the transformation in Slovakia affected the economy for a longer time than in the CR (1999–2006 vs. 1998–2001).

The method pointed out that there was a period of large positive unemployment gaps. In the *economy of the CR* this estimate of the positive gap was marked as the period between the 4th quarter of 2007 and the 4th quarter of 2008 and it corresponded with the development of the unemployment rate and the GDP. The stochastic trend marked the unemployment gap and the boom phase in *industry* as the period from the 2nd quarter of 2007 to the 1st quarter of 2009, in compliance by the real economy data. In *the construction sector* there were positive gaps found in the period starting from the 3rd quarter of 2006 and lasting to the 4th quarter of 2008. A boom phase on the labour market in this way corresponds with the real economy development. Construction can thus be described as a leading indicator. According to the stochastic trend, the estimate of the positive gap and the boom phase in the *economy* overlapped with the estimate of the Kalman filter. Based on the HP filter, this phase began in the 2nd quarter of 2006.

The stochastic trend considers the year 2008 to be the period of the positive gap estimate and the boom phase in *Slovakia*. In *industry* the *positive gaps* were in compliance with the data estimated by the stochastic trend in the period from the 1st quarter of 2006 to the 1st quarter of 2009. If we compare the situation to the one in the CR, we can state that the time periods are approximately the same. The positive gap estimate and the boom phase according to the stochastic trend overlaps with the period estimated by the Kalman filter (in correspondence with the data development the HP filter expanded the period to the year 2007).

Based on the stochastic trend, the influence of the last recession on the labour market in the *economy of the CR* can be tracked in compliance with the data from the 2nd quarter of 2009 to the 1st quarter of 2011. The stochastic trend estimate corresponded with the real development of the labour market. According to the stochastic trend the influence of recession started to be apparent in *industry* in the 2nd quarter of 2009 and lasted until the 2nd quarter of 2010, in compliance with the real data development. In the *construction sector* the recession on the labour market according to the stochastic trend showed in the

period from the 1st quarter of 2009 to the 4th quarter of 2012. *Conclusions made for this period should be regarded as indicative, as the disadvantage of this method, consisting in the fact that NAIRU follows the real values of the specific unemployment rates too closely, was demonstrated.* Based on the stochastic trend the influence of the recession on the labour market in the *economy* can be tracked in compliance with the data just as in the case of the HP filter – that is one quarter in advance of the Kalman filter estimate.

In *Slovakia*, recession started to become visible on the labour market and in the economy from the 1st quarter of 2009 and in the *construction sector* from the 2nd quarter of 2009. The period finished between the 2nd quarter of 2011 and the 2nd quarter of 2012. In *industry* the *influence of recession* became apparent in the period from the 2nd quarter of 2009 to the 2nd quarter of 2011. From the fact that the influence of recession in the selected sectors was delayed after the development of the economy it is clear that other than the observed sectors were more important for the development. Comparison of the two states shows a practical correspondence between the periods of negative influences. However, unlike the HP filter and the Kalman filter, based on the stochastic trend this period lasted only until the 2nd quarter of 2011.

According to the stochastic trend, development of the *Czech economy* in the period between the 2nd quarter of 2011 and the 4th quarter of 2012 was characterised by a phase of shallow boom, which was in line with the development of data. In *industry* the stochastic trend localised a boom phase in the period between the 4th quarter of 2010 and the 4th quarter of 2011. According to the model in 2012 the labour market was again in the phase of recession with a negative unemployment gap. The comparison shows that the indicator of the end of the recession was the industry sector (two quarters ahead of the development of the industry). The development of the *economy* according to the stochastic trend was similar to the development based on the Kalman filter. According to the HP filter, this phase started with a delay of one quarter but it indicated the arrival of the stagnation phase and probability of a new recession.

In *Slovakia* the model of the stochastic trend estimates the positive unemployment gap and the period of shallow boom since the 3rd quarter of 2011, which is in contradiction with the real data. In the *construction sector*, the stochastic trend suggested there was already transition to the boom phase starting from the 2nd quarter of 2012 to the end of the observed period, which was in contradiction with real data. In *industry* the stochastic trend localised a boom phase in the period from the 2nd quarter of 2011 until the end of the observed period. In Slovakia the boom phase returned at first to the industry sector, too (one quarter ahead of the development of the industry and one year ahead of the development in construction). Comparison of the two states shows that these positive tendencies emerged in the CR two quarters earlier then in Slovakia. Given that according to the stochastic trend the estimates for the economy were inconsistent with the real data development, the estimates of the HP filter and the Kalman filter in this phase proved to be more appropriate for estimating NAIRU than the method of the stochastic trend.

The use of the method of stochastic trend for the NAIRU estimate enabled the revelation of dynamising processes in the economy at the sectoral level. The method provides us with more precise beginnings and ends of periods of the economic cycle in the economy as a whole and in sectors. It also enables us to identify leading indicators, which are useful for prediction of the following period. Comparison of consistency/inconsistency between the development of the unemployment gap and the real development of the unemployment

gap and the added value in the economy improved the explanatory power and credibility of NAIRU estimates. The method of stochastic trend should only be regarded as indicative, because of the fact that NAIRU follows the real unemployment rate too closely. In some unstable periods the results of the method were in contradiction with development of real data. Estimates based on methods of the HP filter and the Kalman filter proved to be more appropriate for estimating NAIRU and unemployment gaps.

Note

1. The whole system is defined by seven equations as follows:

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

$$y_t - y^*_t = \varphi(L)(u_{t-1} - u^*_{t-1}) + \varepsilon^{yc}_t \quad (2).$$

The potential output and NAIRU are in the shape of a locally linear trend:

$$y^*_t = y^*_{t-1} + \beta_{t-1} + \varepsilon^{y*}_t \quad (3).$$

$$u^*_t = u^*_{t-1} + \xi_{t-1} + \varepsilon^{u*}_t \quad (4).$$

with two stochastic trends β and ξ as follows:

$$\beta_t = \beta_{t-1} + \varepsilon^{\beta}_t \quad (5).$$

$$\xi_t = \xi_{t-1} + \varepsilon^{\xi}_t \quad (6).$$

The unemployment gap is in the shape of an autoregressive process:

$$u_t - u^*_t = \delta(L)(u_{t-1} - u^*_{t-1}) + \varepsilon^{uc}_t. \quad (7).$$

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Construction deflation
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Manufacturing industry deflator
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Appendix

Table A1. An overview of parameters, *P*-values, selected characteristics of models, and cyclical fluctuations related to the Section 4.3.

	Model parameter			Selected char. of the model		Cyclical fluctuations
Name of the method	Name	Value	*P*-value	*R*-squared	Durbin–Watson stat.	
Slovak Republic Construction						
	Constant	0.00	0.00			
	Unemployment rate (*t*–1)	–0.10	0.01			
	Unemployment rate (*t*–2)	–0.09	0.01			
	Deflator of construction (*t*–1)	0.32	0.03			
	Brent crude oil (*t*)	0.04	0.04			
	Import prices (*t*)	0.65	0.00			
	Model characteristics			0.84	2.00	
	Cyclical fluctuations					
	δ_1					1.50
	δ_2					–0.90

Source: Own calculation based on the data of the Statistical Office of the Slovak Republic and OECD.