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Estimating Potential Growth and Output Gap in Croatia

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Abstract

The purpose of this paper is briefly to present and compare the results of potential growth rate and output gap estimation for Croatia in the period from 1996 to 2016 obtained using three different methodological approaches – the HP filter, the production function method and the multivariate filter (MVF). The results obtained suggest that there are significant quantitative differences between individual estimation methods, so that their use in further calculations calls for caution. The analysis shows that after the global financial crisis, potential growth of the domestic economy and the output gap remained negative over a prolonged period, which is in line with the estimates regularly published for Croatia by the European Commission (EC). It is worth noting that total factor productivity made a small contribution to potential growth rate during the entire period observed and that its growth was much lower than in most European Union countries. This suggests that there are structural problems in the domestic economy that hinder a more effective utilisation of the existing resources.

Keywords:
potential growth, output gap, estimation methods

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E10, E20, E32, E44

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Contents

1 Introduction

Estimates of potential growth and output gap are used in the economic analyses of central banks primarily as an indicator of the business cycle position and its impact on the change in prices in the economy and the stability of the financial system. In addition, potential growth and output gap estimates are also important for fiscal policy analysis and determination of an appropriate character for monetary and macroprudential policies. These variables are used to calculate the structural government deficit, the character of fiscal policy, and its stabilisation role, as well as risks related to the long-term stability of public finances. Due to the described reasons, from the central bank's standpoint, it is important to have reliable estimates of potential growth rates and output gap. However, since these are unobserved variables, their estimation is necessarily characterised by a high level of uncertainty. Also, different estimation methods used in practice are based on different definitions of potential production.

The paper presents the results of an estimation of potential growth and output gap for Croatia in the period from 1996 to 2016 obtained using three different methodological approaches – the production function method, the basic multivariate filter (MVF) and the HP filter. The results show that in the period after the global financial crisis the potential growth of the domestic economy and the output gap were negative over a prolonged period. Such estimates are in line with the estimates published regularly for Croatia by the European Commission. It is worth noting that there exist significant quantitative differences in the estimates of potential growth rate and output gap among the individual methods, which calls for caution in their use in further calculations, e.g. in the cyclically adjusted budget balance or in the assessment of inflationary pressures in the economy. The analysis also shows that, in general, total factor productivity made a small contribution to potential growth during the whole period observed and that its growth was much lower than in most European Union countries. The low growth of productivity suggests that there are structural problems in the domestic economy that hinder a more successful utilisation of the existing resources.

2 Description of methodologies used for the estimation of potential growth and output gap

The HP filter is a univariate statistical filter that decomposes a time series into trend and cycle components. The smoothness of a trend relative to the original series depends on parameter that represents the ratio of variances of shocks in a cycle and a trend. In a state-space form, the HP filter can be written as follows[1]:

$$y_t = \tau_t + c_t$$

$$\tau_t = 2\tau_{t-1} - \tau_{t-2} + \varepsilon_t^{\tau}$$

$$c_t = \varepsilon_t^{c}$$

where y is the observed time series, τ is its trend component, c represents the cycle, while ε^{τ} and ε^{c} are shocks on the trend and the cycle. In the case of the time series of aggregate output (GDP), the trend represents potential output, and the cycle represents the output gap. Usually, $\lambda = 100$ or $\lambda = 6.25$ is used for annual data (see Ravn and Uhlig, 2002).

The use of the HP filter for the estimation of potential growth and output gap involves four basic problems. First, different λ parameter values imply different potential output estimates, so that the end result is arbitrary and depends on user preferences. Second, the HP filter is actually a symmetric two-sided filter and, as a result, estimates towards the end of a given sample period are subject to significant revisions as more data become available (end-of-sample problem). Third, the HP filter represents a purely statistical approach to the potential output estimate, not directly correlated with economic theory. Finally, the HP filter is not an optimal filter for any economic data time series (Hamilton, 2016), therefore, it necessarily results in wrong estimates of the trend and the cycle. The widespread use of the HP filter in practice can primarily be attributed to its simplicity.

The multivariate filter is a hybrid approach to the potential output estimation, which combines the structural analysis of time series[2] with basic macroeconomic relationships, such as the Phillips curve and Okun's law. Within this approach, potential output can be defined as the one that would materialise if prices in the economy were fully flexible. Deviations of inflation from inflationary expectations and deviations of the unemployment rate from its equilibrium level serve as an indicator of whether movements in the economy are caused by shocks on the demand side (output gap) or the supply side (trend level and growth rate). The advantages of the MVF are that it takes economic theory into consideration in potential output estimations, that it is relatively simple to use and that it requires the availability of only few core variables for the estimation (GDP, inflation and unemployment rate). Also, this method is generally more robust to the end-of-sample problem than univariate filters, such as the HP filter (although the problem is still pronounced). On the other hand, the greatest disadvantage of this approach is evident in the fact that its quality depends on whether specified macroeconomic relationships are actually valid in the analysed economy.

The production function method implicitly defines potential output as the level of production that can be achieved over a long period without an excessive utilisation of the existing productive capacity. In its basic form, this approach starts from the definition of the production function form, most frequently with two observed production factors and total factor productivity that is derived as a residual from the production

1 A better known definition is that the HP filter is the solution to the following optimisation problem:

$$y_t = \tau_t + c_t$$

$$\min(\tau_t) = \sum_{t=1}^{T}(y_t - \tau_t)^2 + \lambda\sum_{t=2}^{T-1}[(\tau_{t+1} - \tau_t) - (\tau_t - \tau_{t-1})]^2$$

2 The structural analysis of time series is based on the assumption that the time series observed can be decomposed into the sum or the product of the appropriately selected components such as trend, cyclical, seasonal and irregular components. Each component is assumed to follow a certain autoregressive integrated moving average (ARIMA) process.

function equation. In practice, the Cobb-Douglas production function is most frequently assumed:

$$Y_t = TFP_t \cdot L_t^{\beta} \cdot C_t^{(1-\beta)}$$

where Y denotes output, L is the quantity of labour applied, C is the quantity of capital, while TFP is total factor productivity. Parameter β is the labour factor share in output. After defining the production function, long-term trends are estimated from the time series of labour, total factor productivity and capital, and then the potential output estimate is derived from the production function equation. The greatest advantage of this method is that it helps divide potential growth into the contributions of labour, capital and total factor productivity. On the other hand, disadvantages are reflected in the difficulty of making a reliable estimate of trends of time series, so that the potential output estimate is good to the extent to which long-term trends of labour, total factor productivity and capital are well estimated. The production function method is most frequently used in practice, the CNB, the European Central Bank and the European Commission, among others, using it in their analyses.

3 Data used and estimation method

The estimates of potential growth and output gap were prepared for the period from 1996 to 2016. The relevant series used in estimates were extended by official CNB projections for the subsequent two years (2017 and 2018) to reduce the end-of-sample problem. The estimates based on the HP filter were made for $\lambda = 100$ and $\lambda = 6.25$. The multivariate filter was estimated using Bayesian methods based on GDP, unemployment and consumer price inflation rates and world oil prices as observed variables[3]. The Croatian Bureau of Statistics (CBS) is the source for the first three series, while world oil prices were taken from the FRED database[4]. The Bayesian estimate of parameters and variances of shocks is a compromise between their classical estimation and calibration. It is particularly favourable when the sample on which the estimate is carried out is short[5]. Finally, the production function method assumes that it is of a Cobb-Douglas form, with the shares of labour and capital being calibrated to 0.65 and 0.35 (see, for example, Havik et al., 2014). The time series used in the estimation are, as follows: GDP, the unemployment rate, average hours worked per employee, participation rates in the labour market, working age population (source CBS) and the total capital stock constructed using the perpetual inventory method (PIM). The trend in employment (measured by overall average hours worked in the economy) and total factor productivity was estimated using the HP filter. The trend was not removed from the capital series[6].

4 Estimation results

Figure 1 shows estimated potential growth rates (left) and output gap (right) derived based on the described methods. It is worth noting that only mean values of the obtained estimates are shown, without the uncertainty that surrounds each one of them.

Results show that the potential growth in the domestic economy was positive and relatively high from 1997, while from 2004, it started to decrease and became negative after the outbreak of the global financial

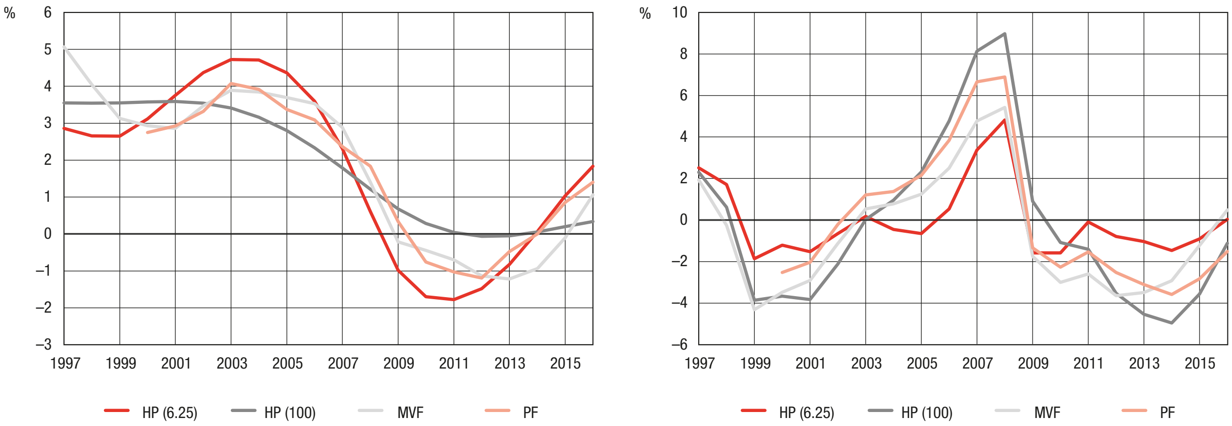
3 The model used is described in more detail in Appendix 2.

4 Federal Reserve Economic Data (FRED) is a database maintained by the Federal Reserve Bank of St. Louis.

5 See Appendix 3 for more details on the Bayesian approach to model estimates.

6 See Appendix 1 for more details.

Figure 1 Estimates of potential growth (left) and output gap (right) using different methods



Note: HP(6.25) = HP filter with λ = 6.25, HP(100) = HP filter with λ = 100, MVF = multivariate filter, PF = production function method.
Sources: CBS, FRED and author's calculation.

crisis (HP filter with $\lambda = 100$ is the largest exception). It is worth noting that all estimates show that since 2015 the potential growth rate of the domestic economy has been positive again. Output gap was negative from the 1999 banking crisis until 2003, however, it grew strongly over the subsequent years, and the highest positive value was recorded in 2008. Its values have been negative since the outbreak of the global economic crisis, when it fell sharply. However, at the very end of the analysed period, the closing of the negative gap is noticeable.

It is worth noting that there are certain qualitative differences in the obtained estimates, depending on the method used; however, these differences are not too pronounced. Thus, for example, the production function method and the HP filter with $\lambda = 6.25$, unlike the MVF, show that the potential growth was positive by 2014. The HP filter with $\lambda = 6.25$ and the MVF, in contrast to the other two methods, also indicate a mildly positive value of the output gap in 2016. At the same time, however, there are significant differences in the values of estimated potential growth rates and output gaps. For instance, the HP filter with $\lambda = 100$ gives an estimate of the output gap of almost 9.0%, the MVF of 5.6%, the production function method of 6.9%, while the HP filter with $\lambda = 6.25$ gives an estimate of 4.8% in 2008. The results call for caution in the selection of the method for gap estimation, in particular when they are the basis for the calculation of values such as cyclically adjusted government deficit or inflationary pressures, which may lead to policies that are not in line with the actual cyclical position of the economy.

Table 1 Cyclically adjusted budget balance of the general government

	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
HP (100)	–4.8	–5.3	–5.7	–6.4	–6.4	–5.8	–7.3	–3.9	–3.5	–3.4	–1.9	–1.4
HP (6.25)	–3.6	–3.6	–3.8	–4.7	–5.4	–5.6	–7.8	–5.0	–4.9	–4.8	–2.9	–1.8
MVF	–4.4	–4.9	–5.2	–5.9	–6.0	–5.4	–7.0	–3.7	–3.3	–3.4	–1.9	–1.3
PF	–4.7	–4.9	–5.1	–5.5	–5.5	–5.3	–7.2	–4.3	–4.1	–4.0	–2.2	–1.2

Note: HP(6.25) = HP filter with λ = 6.25, HP(100) = HP filter with λ = 100, MVF = multivariate filter, PF = production function method.

As an illustration, Table 1 shows the values of the cyclically adjusted (structural) budget deficit of the general government calculated using different output gap estimates. In this case, the cyclically adjusted deficit is calculated by multiplying the output gap by the coefficient of deficit sensitivity to cyclical movements in the economy and then subtracting this value from the nominal deficit (in percentage of GDP)[7].

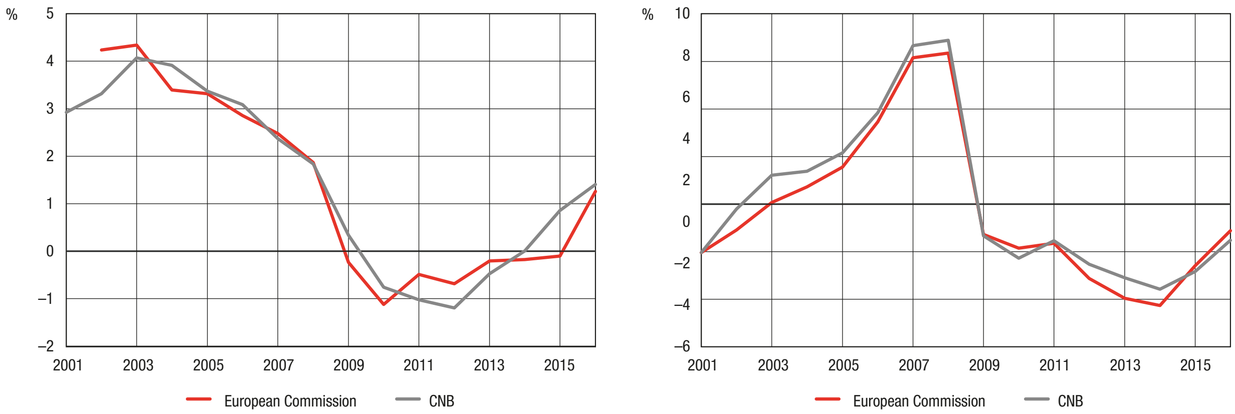
7 This method of calculation of the cyclically adjusted balance is similar to the one used by the European Commission.

As can be seen, there are significant differences between structural budget deficit values depending on the estimation method used to calculate the output gap. As a result, the estimates of the size of the fiscal space for the implementation of countercyclical policies is characterised by a noticeable level of uncertainty.

5 Comparison with estimates of potential growth and output gap of the European Commission

The obtained estimates of potential growth and output gap for Croatia are compared with those prepared and published by the European Commission (EC). The European Commission calculates the cyclically adjusted structural budget balance based on gap estimates to assess whether the EU member states comply with the provisions of the Stability and Growth Pact.[8] Due to the legal importance and the consequences of the results, the methodology used by the EC is strictly prescribed and the member states revise it on a regular basis.[9] The EC's estimates are based on the production function methodology. It differs from the approach used by the CNB in the manner of estimating the trend in the employment rate.[10] Therefore, the EC and CNB estimates are very similar, in particular if the uncertainty that characterises them is taken into account (see Figure 2).

Figure 2 CNB and EC's estimates of potential growth (left) and output gap (right)



Notes: The estimates are based on the production function method. The European Commission's estimate from February 2017 was downloaded from https://circabc.europa.eu.
Sources: European Commission, CBS and author's calculation.

8 The calculation of the structural budget balance is also important in the framework of the excessive deficit procedure and in the SGP's preventive arm, in which countries should maintain the structural deficit at the level of the medium-term objective (MTO).

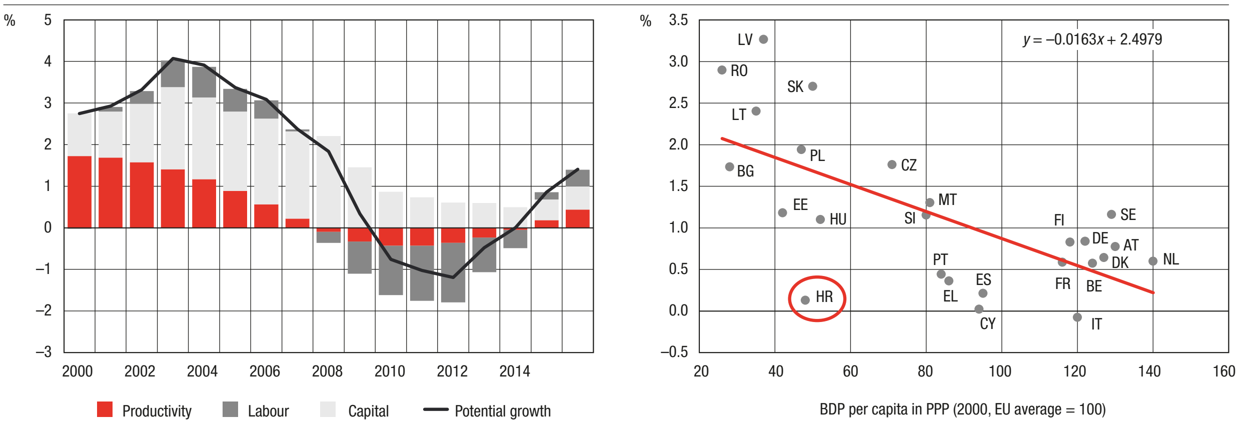
9 The Output Gaps Working Group is a sub-committee of the Economic Policy Committee of the EU Council, http://europa.eu/epc/output-gaps-working-group_en.

10 More precisely, the largest difference in the manner of estimating the trend in the unemployment rate, which is included in the estimation of the employment trend through identity $L = H \cdot (1 + UNR) \cdot PART \cdot POP$ where L is total employment measured in hours worked, H is average hours worked per employee, UNR is the unemployment rate, $PART$ is the participation rate, and POP is the total working age population. As described in Appendix 1, the CNB uses the Elmeskow method (see Elmeskow and MacFarland, 1993) combined with the HP filter, while the European Commission uses the multivariate filter, which uses the Phillips curve for the identification of the cyclical component of the unemployment rate (Havik et al., 2014).

6 Production factor contributions to potential growth

Finally, it is expedient to explore further the decomposition of the potential growth rate (estimated using the production function method) made at the CNB on production factor contributions as it can point to potential problems of the domestic economy. Figure 3 shows that the largest negative contribution to potential growth after the global economic crisis came from the labour production factor, which was attributed to a declining participation rate and a growing trend of the equilibrium unemployment rate. This shows that there are imbalances in the domestic labour market. At the same time, a generally small contribution of total factor productivity to potential growth during the entire observed period is also worth mentioning. Moreover, if productivity growth in the domestic economy in the past sixteen years is compared with growth in EU countries, it is obvious that Croatia is significantly lagging behind most of the countries. The low growth of productivity suggests that there are considerable structural problems in the domestic economy that hinder a more successful utilisation of the existing resources. In this context, policies focusing on the identification and elimination of such problems might have a favourable impact on the long-term growth of the economy.

Figure 3 Decomposition of the potential growth rate (left) and comparison of productivity growth in Croatia and EU countries (right)



Notes: The decomposition of potential growth is based on the production function method. The comparison of the TFP growth rates was conditional on the level of relative GDP per capita adjusted by the purchasing power parity (PPP).
Sources: European Commission, Eurostat, CBS and author's calculation.

7 Conclusion

This survey presents the results of the potential growth and output gap estimates for Croatia in the period from 1996 to 2016 derived using three different methodological approaches – the HP filter, the basic multivariate filter (MVF) and the production function method. The obtained results show that there are noticeable quantitative differences in the obtained estimates, depending on the method used. This means that caution is advised in the use of the potential growth or output gap estimates in further calculations, such as the estimates of the cyclically adjusted balance or the estimate of inflationary pressures in the economy. When it comes to contributions of production factors and total factor productivity, it is worth noting that, in general, the latter made a small contribution to potential growth during the whole period observed and that its growth was much lower than in the majority of EU countries. Low productivity growth suggests that there are structural problems in the domestic economy that hinder a more efficient utilisation of the existing resources. In this context, policies focusing on the identification and elimination of such problems might have a very favourable impact on the long-term growth of the economy.

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Appendix 1 Production function method

The aggregate production function is in a Cobb-Douglas form with constant returns to scale. The shares of production factors are calibrated and assumed to be fixed:

$$Y_t = TFP_t \cdot L_t^{0.65} \cdot C_t^{0.35}$$

where Y is aggregate output measured by GDP, TFP is total factor productivity, L is employment measured by total hours worked, and C is total productive capital stock. The capital stock was calculated using the perpetual inventory method (PIM) under the assumption of 5% annually.

The procedure used for the estimation of potential output is relatively simple. First, TFP is obtained as a residual from the production function equation and then its value is forecast for three years in advance based on historical trends and any available additional information. The trend component of total factor productivity $(\overline{TFP})$ is then derived using the HP filter with smoothing parameter $\lambda = 100$. The expansion of the TFP series by forecast values before filtering serves to mitigate the end-point-bias problem characteristic for two-sided univariate filters such as the HP filter.

Second, the estimates of the trend in employment are obtained by applying the following identity:

$$L_t = HW_t \cdot (1 - UNR_t) \cdot PART_t \cdot POP_t$$

where HW denotes average hours worked per employee, UNR is the unemployment rate, $PART$ is the participation rate, and POP represents the working age population (aged $15 - 64$). The projections of population movements are taken from the CBS. Trends in the participation rate and average hours worked per employee are obtained in a similar manner as the TFP trend. More precisely, both series are forecast three years in advance and trends are then obtained using the HP filter $(\lambda = 100)$. The unemployment rate trend is calculated in three steps. In the first step, the non-accelerating wage rate of unemployment (NAWRU) is estimated using the Elmeskow method (see Elmeskow and MacFarland, 1993). In the second step, the NAWRU is forecast three years in advance based on the optimal ARIMA process and any additional available information. Finally, in the third step, the unemployment trend is derived using the HP filter with $\lambda = 100$. The trend of total hours worked is derived $(\overline{L})$ by including the thus estimated trends in the above identity.

Third, due to the absence of reliable indicators of production capacity utilisation, the original capital stock series is used in the potential output estimation. In other words, it is assumed that the capital is utilised in its entirety the whole time. The potential output estimate is derived by including the estimates of the trend in total factor productivity, total hours worked and capital into the production function:

$$\overline{Y}_t = \overline{TPF}_t \cdot \overline{L}_t^{0.65} \cdot C_t^{0.35}$$

After the potential output estimate is obtained, the calculation of the output gap and potential growth rate is simple. In addition, based on the above equation, the contributions of production factors and TFP to potential growth are easily calculated.

Appendix 2 Description of the multivariate filter model

The model structure is similar to the one presented in Blagrave et al. (2015)[11]. It is assumed that GDP logarithm (y) can be decomposed into a trend ($\bar{y}$) and a cycle (gap):

$$y_t = \bar{y}_t + gap_t$$

In addition, it is assumed that stochastic processes for GDP trend and cycle are of the following form:

$$\bar{y}_t = \bar{y}_{t-1} + g_t + \varepsilon_t^{\bar{y}}$$

$$g_t = (1-\theta)g_{ss} + \theta g_{t-1} + \varepsilon_t^{\bar{g}}$$

$$gap_t = \phi gap_{t-1} + \varepsilon_t^{gap}$$

where g_t is the trend growth rate, $\varepsilon_t^{\bar{y}}$ and $\varepsilon_t^{\bar{g}}$, ε_t^{gap} and are shocks on the level of potential output, potential growth rate and output gap. The latter shock may be interpreted as demand shock. In the absence of shocks, output would grow at an equilibrium rate (g_{ss}). In order to identify the above mentioned shocks, the model contains the Phillips curve, which links the output gap with inflation (π):

$$\pi_t = \lambda\pi_{t+1} + (1-\lambda)\pi_{t-1} + \varkappa gap_t + v\Delta poil_t + \varepsilon_t^{\pi}$$

In addition, the Phillips curve assumes that inflation depends on the change in oil prices ($\Delta poil$). Finally, the model also includes the equations that describe the movement of the unemployment rate (π), which enables a better identification of the output gap:

$$u_t = \bar{u}_t + ugap_t$$

$$\bar{u}_t = (1-\varphi)u_{ss} + \varphi\bar{u}_{t-1} + g\bar{u}_t - \zeta gap_{t-1} + \varepsilon_t^{\bar{u}}$$

$$g\bar{u}_t = \tau g\bar{u}_{t-1} + \varepsilon_t^{g\bar{u}}$$

$$ugap_t = \rho ugap_{t-1} + \beta gap_t + \varepsilon_t^{ugap}$$

As in the case of output, it is assumed that the unemployment rate can be decomposed into the trend ($\bar{u}$) and cycle ($ugap$) components, whose processes are described by the three equations shown above. The shocks of $\varepsilon_t^{\bar{u}}$, $\varepsilon_t^{g\bar{u}}$ and ε_t^{ugap} are shocks on the unemployment rate equilibrium level, its growth and the unemployment gap. It is important to note that this model version allows the trend or the equilibrium unemployment rate to depend on the output gap (hysteresis effect).

11 The model structure is simpler than the one in Bokan and Ravnik (2012), who have also used the multivariate filter for potential output estimation.

Appendix 3 Basics of the Bayesian approach to model parameter estimation

Unlike the classical estimation methods, such as the maximum likelihood method, the Bayesian approach enables the inclusion of prior information in the model parameter estimation process. This approach is based on Bayes' Theorem, which says that the distribution of model parameters conditional on data, $p(\theta \mid Y)$, which is usually called posterior distribution of parameters, equals:

$$p(\theta \mid Y) = \frac{p(Y \mid \theta)p(\theta)}{p(Y)}$$

That is, $p(Y, \theta)$ is a joint distribution of data Y and model parameters θ. Therefore, this joint distribution can be decomposed into the distribution of data conditional on model parameters, $p(Y \mid \theta)$, also called the likelihood function, and a prior distribution of parameters, $p(\theta)$, which is independent of data. At the same time, it may, of course, be factorised into the distribution of parameters conditional on data, $p(\theta \mid Y)$ and the distribution of data, $p(Y)$. Bayes' Theorem is obtained from their combination.

In short, the likelihood function summarises the information on parameters revealed by the data, while the prior distribution of parameters summarises the data from all other sources (e.g. from previous studies). A posterior distribution of parameters is obtained from a combination of these two sets of information. The advantage of including prior information is particularly convenient in cases in which the sample on which the estimation is carried out is short and when data do not contain sufficient information for a precise estimation of individual parameters. In such cases, it often happens that classical estimation methods lead to estimated values of parameters that are not economically plausible. The relative importance of prior information for the estimation of model parameters depends on its relative importance in relation to the information contained in the data, which, in the Bayesian approach can be controlled using the variance of prior distributions of individual parameters. Therefore, if the variance of a prior distribution of a parameter is very large, this means that a posterior estimation will almost fully reflect the information contained in the data. If, however, the variance of a prior distribution is small, the posterior estimation will primarily reflect the information contained in the prior.

Except in special cases, a posterior distribution does not have a standard form (consequently, it cannot be evaluated analytically), but is instead approximated using numerical methods. In general, only a prior distribution of parameters, $p(Y)$ and the likelihood function $p(Y \mid \theta)$ can be evaluated, which is not a problem for estimation because $p(Y)$ is only a constant so that a posterior distribution is proportional to $p(Y \mid \theta)p(\theta)$. The numerical evaluation of a posterior distribution implies that a series of parameters θ is generated from $p(Y \mid \theta)p(\theta)$ using a Monte Carlo algorithm. It can be shown that averages of thus generated series satisfy a strong law of large numbers and often also the central limit theorem (Herbst and Schorfheide, 2015). Based on series so generated, posterior distributions of different linear and non-linear functions of model parameters, e.g. impulse response functions, may be constructed and eventually evaluated.

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