SELECTED METHODS FOR ESTIMATING OUTPUT GAP OF THE SLOVAK REPUBLIC

Ľubica Štiblárová – Marianna Siničáková

Abstract

The aim of the article is to apply and evaluate different approaches to estimate potential output and output gap of the Slovak Republic. We decided to apply statistical method Hodrick-Prescott filter, structural method of production function and alternatively principal component analysis to identify common cyclical component of the indicators. Several differences were observed among used methods, predominantly at the end of selected period. Similar results were given in period from 2006 to 2008 which can be identified as a period of great expansion and overheating of economy.

Key words: business cycle, output gap, production function, principal component analysis

JEL Code: E32, E23, C38

Introduction

Knowledge of recent economic development and its proper estimation represent a key instruments for optimal implementation of economic policy. The aim of economic policy is to achieve level of output not leading to internal or external imbalances; in case of overheating of an economy, actual output higher than the potential level does not ensure price stability and causes inflation. In case of recession, low performance of an economy leads to an increase of unemployment and deflation pressure. Forecasting and applying economic and political decisions without correct information would not serve to achieve desirable level of economic activity. From that reason, detection of the business cycle phase thus output gap of an economy is crucial in selection of optimal monetary policy instruments leading to internal and external balance.

The aim of our paper is to apply various methods to estimate the potential output and output gap of the Slovak Republic, compare its results and evaluate which method could be the most suitable in this case. The structure of paper is organized as it follows. First part provides a definition and review on potential output and output gap. Second part describes methodology and data used to estimate output gap of the Slovak economy. Section 3 presents

empirical results and discussion, as well as a comparison with results from international organizations and central bank. Finally, we provide some final conclusions and summarize our results.

1 Theories of economic cycle and business cycle fluctuations

Various theories introduce an explanation of the cyclical evolution of economic activity. According to Zimková and Barochovský (2007), exogenous and endogenous factors contribute to the fluctuation of output; exogenous factors involve e.g. political crises, economic crises and wars, whereas endogenous comprise investment expenditure and its instability. Theories of real and monetary cycles provide us with different views on this matter. The existence of real cycles (Kydland and Prescott, 1982) supposes shocks on the side of aggregate supply, namely technological changes boosting economic growth which is followed by rapid deceleration. Theory of monetary cycle (Hahn and Lucas, 1988) identifies changes in monetary base leading to changes in aggregate demand as a main source of business cycles of an economy. Although these theories are not opposite, cyclical fluctuations can be caused by various parallel determinants. In addition business cycles can be analysed in terms of their size (amplitude) and duration (length) (Yildirim, 2015).

Identification of the cyclical evolution – an output gap of an economy, is crucial for a number of reasons; concerning business cycle synchronization as a one of the main conditions of optimal currency area (Mundell, 1961), setting interest rate in implementing effective monetary policy, detecting structural primary budget balance in fiscal policy, regulating labour policy, tax policy, etc. Apparently, actual output does not exactly follow its potential level and deviate from this desirable level. For that reason, the output gap can be defined as the percentage deviation of an economy's total output from its potential level. Potential output represents important supply side indicator which can be defined from internal and external balance point of view. In case of internal balance, it is defined as a level of output that does not initiate inflation pressure. In case of external balance, if actual output reaches a level of potential output, it may not initiate current account deficit/surplus.

The problem is that this indicator is unobservable. It is a notorious fact that these unobservable variables are impossible to measure and, consequently, estimates differ widely depending on the methods used (Canova, 1998). Besides conventional approaches, alternative methods can be used as a supplement. These methods can be divided into (Kloudová, 2013): i.

statistical methods, ii. structural methods, iii. semi-structural methods, iv. methods using direct indicators.

2 Methodology and data

To estimate output gap of the Slovak economy, we decide to apply three methods. We chose statistical method – Hodrick-Prescott filter as the most frequent method, production function as a structural method and finally, we decided to use non-traditional, principal component analysis – as an alternative to previously stated methods.

We use data from the Statistical Office of the Slovak Republic, National Bank of Slovakia and Eurostat. Time series of real GDP were calculated by our own from deflator and nominal GDP – we used seasonally adjusted data covering period 1997Q1-2015Q4. All the calculations were performed in the R environment.

2.1 Hodrick-Prescott filter

Time series of real GDP by Hodrick-Prescott (HP) filter is decomposed in two components – trend (g_t) and cyclical part (c_t). HP filter estimates cyclical and trend component by minimizing following equation:

$$\min_{g_t}\left[\sum_{t=1}^{N}(y_t - g_t)^2 + \lambda\sum_{t=2}^{N-1}\left[(g_{t+1} - g_t) - (g_t - g_{t-1})\right]^2\right] \qquad (1)$$

whereas smoothing parameter was set as 1600 as it is recommended with quarterly data (Ravn and Uhlig, 2002).

2.2 Production function approach

Here we decided to apply Cobb-Douglas form of the production function:

$$Y^* = A^* \cdot L^{*\alpha} \cdot K^{*1-\alpha} \qquad (2)$$

where Y^* denotes potential output, L^* and K^* refer to potential (full-employment) labour and capital respectively, A^* denotes potential total factor productivity (TFP), and α represents the labour elasticity of output.

Output gap calculated by this method relies on the economic theory and has meaningful interpretation (unlike the previous method). However, calculation is much more complicated due to the character of needed information – it requires identification or more likely estimation of full-employment labour and capital inputs, potential total factor productivity and the labour elasticity of output. Total factor productivity represents efficient use of factor inputs (capital and labour) and can be computed as the Solow residual of capital

and labour from time series of real GDP. After that, its potential level can be measured as a trend component of total factor productivity retrieved by some filtering techniques (e.g. Hodrick-Prescott filter). Equilibrium employment can be computed directly as a trend component of available labour force or indirectly by retrieving equilibrium unemployment (e.g. NAIRU, NAWRU) from labour input. Particularly, most complicated is to find reliable data about capital stocks. For this purpose, we used perpetual inventory method to estimate the initial level of the real capital stock and then calculated actual capital stock as a sum of current fixed investment of past capital stock adjusted for depreciation (we used rate of depreciation 0.04). Finally, we considered 0.52 for labour elasticity of output as it is assumed by Ministry of Finance of the Slovak Republic or Konuki (2010) for the Slovak economy.

2.3 Principal component analysis (PCA)

The PCA could serve as a suitable technique allowing us to identify common cyclical component of a number of indicators (primarily soft indicators from business or consumer surveys, cyclical indicators reflecting business cycles labour market, financial market, etc.). It represents statistical method that converts a set of correlated variable into a set of orthogonal, linearly uncorrelated variables, so-called principal components.

The first principal component presents the linear combination with the greatest variance. It can be considered as a proxy for the output gap due to the assumption that the output gap is the most common determinant of the cyclical indicators (Pybus, 2011). To use this method, we standardized data, used Kaiser-Meyer-Olkin criterion comparing correlation coefficients with partial coefficients and applied orthogonal rotation VARIMAX.

3 Results and discussion

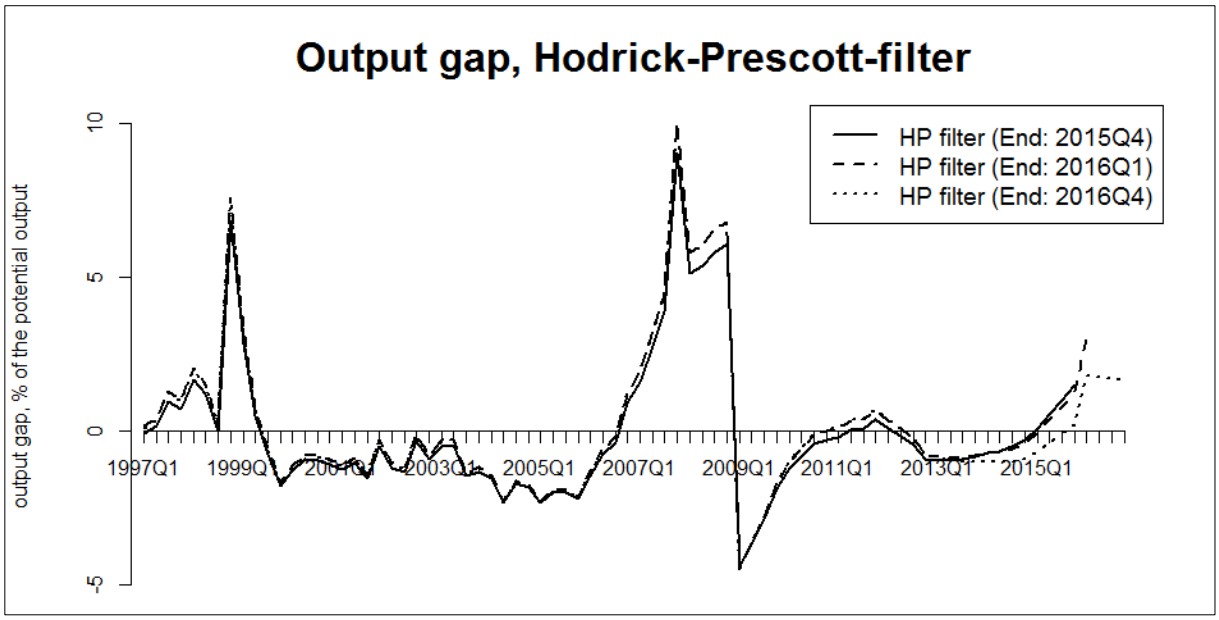
3.1 Output gap of the Slovak Republic using Hodrick-Prescott filter

Firstly, we decided to apply Hodrick-Prescott filter as it belongs among the most frequent used methods.

Figure 1 represents an estimation of the output gap for the Slovak Republic using HP filter. According to this method, Slovak economy was in recession from fourth quarter of the year 1999 to the third quarter of 2006. Economic boom in 2006 and 2007 is captured by outstanding positive output gap, especially at the end of the 2007. Financial and economic

crisis has been revealed in the first quarter 2009 and the recovery of the economy represented by the positive output gap appeared in the 2011.

Fig. 1: Estimation of the output gap by HP filter



Source: own calculations based on data from Eurostat

Besides the advantages of this method (simplicity of calculation and need of input data), the biggest disadvantage of this method can be seen at the end of the selected period as so-called "end-point bias". Therefore extrapolation of the data is recommended – in Figure 1 we present considerable differences of results without extrapolation (solid line), results with forecast for the next quarter (dashed line) and results with the forecast for the next year (dotted line). Furthermore, results from this technique depend greatly on the choice of the smoothing parameter lambda as it is strictly statistical method. Especially for the end-point bias problem, Hodrick-Prescott filter without extrapolation is inappropriate for predictions of time series.

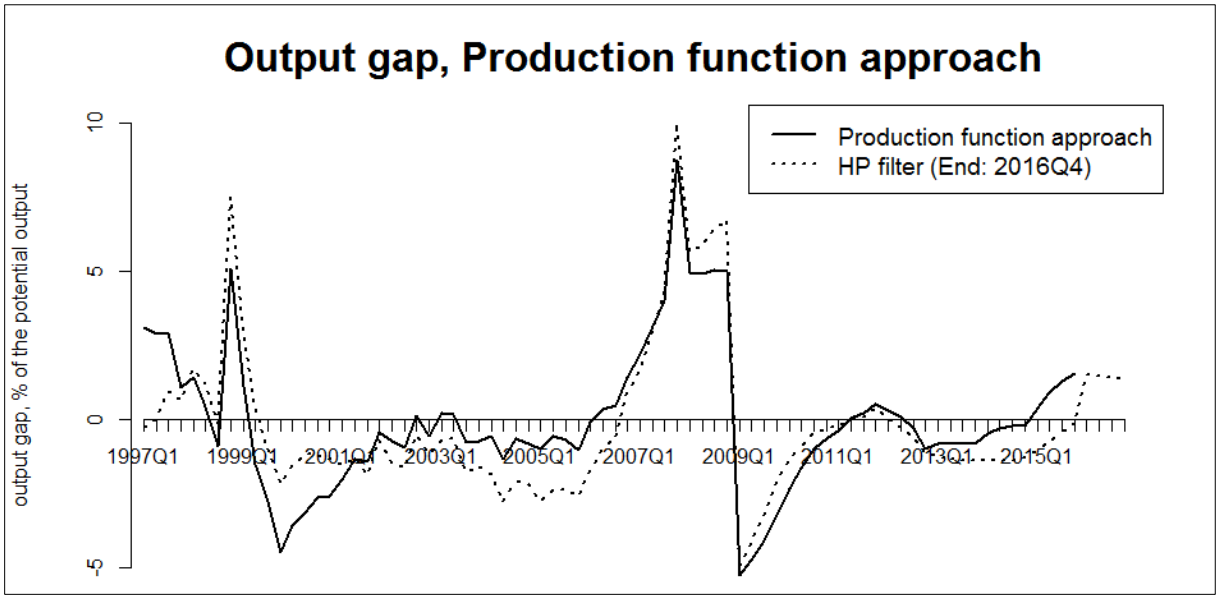
3.2 Output gap of the Slovak Republic using production function approach

To compare results from Hodrick-Prescott filter, we decided to use production function approach.

Output gap estimated by the production function approach is notably higher in period 2002–2007 (in some cases even positive) than those estimated by the HP filter (Figure 2). On the other hand, from 1999 to 2001 output gap estimated by production function seems to be highly negative. We cannot see only different extent of output gaps, but also different phases

of business cycles – e.g. in the second and third quarter of 2006, we assume expansion by the production function approach, although results by HP filter signal recession. Despite of this fact, both methods indicates overheating of the economy at the end of 2007.

Fig. 2: Estimation of the output gap by production function approach



Source: own calculations based on data from Eurostat

This structural method based on economic theory has stronger economic interpretation and logically explains economic situation in a country. It models economic factors – equilibrium employment and capital determining the level of potential output. However, these parameters are not directly available (as well as total factor productivity) and need to be estimated, so the problem of filtering techniques is still present, just delegated on the lower level.

Tab. 1: Summary of output gap estimates

	NBS	EC	MoF SR	OECD	**PF**	**HP**
2010	-1.6	-0.4	-0.8	1.0	-1.4	-0.6
2011	-1.01	-1.2	-0.8	0.5	0.9	0.2
2012	-1.31	-2.1	-1.1	-0.9	-0.3	-0.3
2013	-1.76	-2.9	-1.7	-2.2	-0.9	-1.1
2014	-1.72	-2.9	-1.3	-2.3	-0.4	-1.2
2015	-0.91	-2.6	-1.1	-1.9	1.3	-0.4
2016*	-0.8	-1.8	-0.5	-1.3	X	X

2017*	-0.5	-1	0	-0.8	X	X

Source: NBS, EC, MoF SR, OECD estimates and own calculations based on data from Eurostat

Estimates can be also adjusted due to the noncyclical shocks – e.g. large FDI inflows in 2006–2008 could have a large impact on potential total factor productivity and equilibrium employment. In Table 1 we provide summary of our results from production function and HP filter, moreover comparison with results from National Bank of Slovakia, OECD, European commission and Ministry of Finance of the Slovak Republic. Similarly, OECD and European Commission (EC) use production function approach. As previously mentioned, Ministry of Finance adjusts results from production function in order to incorporate non-cyclical shocks. National Bank of Slovakia uses a small-scale gap model in order to estimate output gap of an economy (Gylánik and Huček, 2009).

Our results overall correspond to the official one, however, end of period is affected by the end-point bias in both – PF method and HP filter. Besides our estimates, output gaps of monetary authority and other organizations have to be completed with expert judgments and therefore other methods should be implemented.

3.3 Output gap of the Slovak Republic using principal component analysis

We chose principal component analysis (PCA) as an alternative method to estimate output gap of the Slovak Republic. Several combinations of indicators reflecting cyclical development of the Slovak economy were considered. After many replications, we decided to run the PCA with 8 cyclical indicators that should mostly reflect business fluctuations.

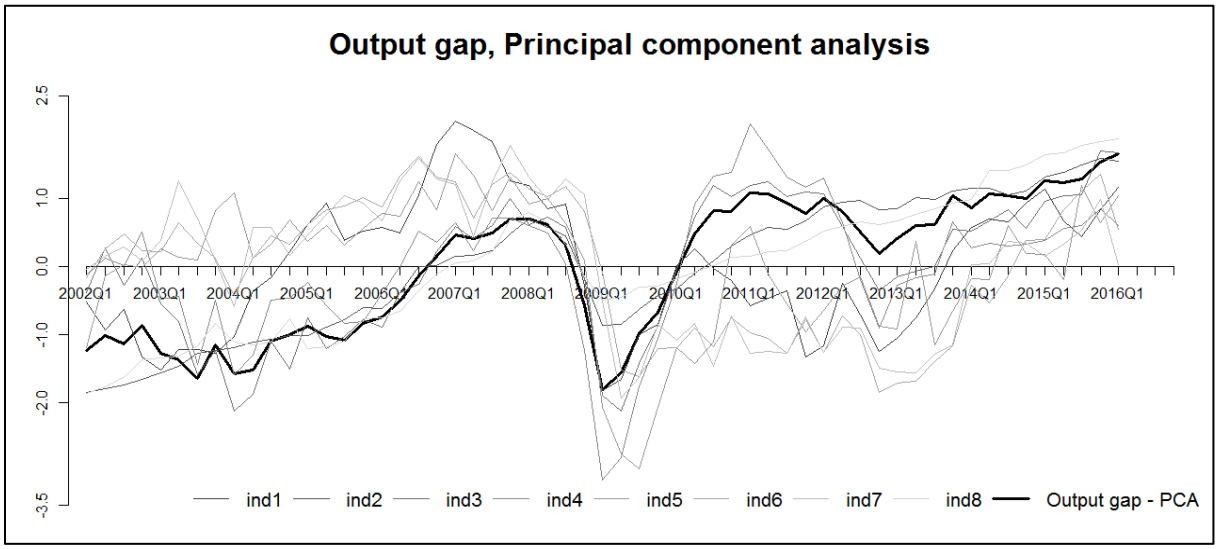
Tab. 2: Principal component analysis summary and correlation matrix

	Eigen value	PCA Loadings	ind1	ind2	ind3	ind4	ind5	ind6	ind7	ind8
ind1	3.66	0.46	1.00							
ind2	2.84	0.93	0.40	1.00						
ind3	0.79	0.91	0.43	0.73	1.00					
ind4	0.32	0.77	0.40	0.51	0.88	1.00				
ind5	0.27	0.19	0.61	0.11	0.24	0.37	1.00			
ind6	0.05	-0.11	0.62	-0.14	0.03	0.05	0.72	1.00		
ind7	0.04	-0.15	0.59	-0.17	-0.01	0.02	0.71	0.96	1.00	
ind8	0.02	0.89	0.39	0.97	0.69	0.42	0.08	-0.10	-0.14	1.00

Source: own calculations based on data from NBS and Eurostat

In Table 2 we provide eigen values, standardized loading from PCA and correlation matrix of these indicators. First component explains about 50 % of variance of data. Primarily, we used survey indicators from the database of the National Bank of Slovakia: consumer confidence index, industrial revenue, employment, expected number of employees in industry, capacity utilization in industry, construction confidence index, expected number of employees in construction and index of industrial production.

Fig. 3: Estimation of the output gap by principal component analysis



Source: own calculations based on data from NBS and Eurostat

Figure 3 captures output gap estimated by the principal component analysis (bold line). As we had to standardized data, it should be advisable to rescale them, but even without rescaling, we can see evident similarity to the results from the production function or HP filter from the Figure 2. Recession breakout in 2009, overheating of the economy in 2006 and 2007. Although we get different results for the start and end of selected period – according to previously used methods, PCA suggests continuing expansion in 2016, whereas NBS, OECD or EC predict negative output gap development in the next period. The main disadvantage of the PCA is the subjective choice of cyclical indicators, although it can be used as a supplement of the traditional methods.

Conclusion

Potential output and output gap represent important indicators in monetary policy decision-making process. However, these variables are not directly observed and different methods can

be used only to estimate them. In economic literature there is not a consensus which method is the most suitable until now. We decided to apply and evaluate three methods in case of the Slovak Republic: Hodrick-Prescott filter, Cobb-Douglas production function approach and alternatively, principal component analysis. We reminded main limitations and benefits of each method; differences in results were detected notably at the end of selected period (year 2015 and 2016), but overheating of an economy in 2007 is captured by each method.

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Contact

Ľubica Štiblárová
Faculty of Economics, Technical University of Košice
Němcovej 32, 040 01 Košice, Slovakia
lubica.stiblarova@tuke.sk

Marianna Siničáková
Faculty of Economics, Technical University of Košice
Němcovej 32, 040 01 Košice, Slovakia
marianna.sinicakova@tuke.sk