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FINDING YETI

MORE ROBUST ESTIMATES OF OUTPUT GAP IN SLOVAKIA

Ľudovít Ódor,
Judita Jurašeková Kucserová

WORKING PAPER

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www.nbs.sk
Imricha Karvaša 1
813 25 Bratislava

research@nbs.sk

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Finding Yeti[1]

Working paper NBS

Ľudovít Ódor[2], Judita Jurašeková Kucserová[3]

Abstract

Estimates of potential output and the output gap are essential elements in the toolkit of policy makers. Latest changes in the European fiscal framework have strengthened significantly the role of structural budget balances, which rest on output gap calculations. With the adoption of the Fiscal Compact new procedures are entering into force. Independent fiscal institutions are going to play an important role in triggering correction mechanisms. In our view, the new framework will be credible only if meaningful estimates of output gaps and structural budget balances are available in real time. This is a huge problem especially for small countries with short history and many structural breaks, where the estimation of output gap is more an art than a science. Very volatile estimates of output gap with weak information content can quickly undermine the credibility of independent fiscal institutions. In this working paper we critically review the current estimation techniques in Slovakia and propose a new framework to calculate more robust output gap figures. In a companion paper we deal with possible improvements in the estimation of structural budget balances.

Keywords: output gap, real-time evaluation, fiscal policy, principal component analysis, multivariate Kalman filter
JEL classification: E23, C22, C32

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[2] Council for Budget Responsibility, odor@rrz.sk
[3] National Bank of Slovakia, judita_jurasekova@nbs.sk

1 MOTIVATION

Output gaps play an important role in understanding underlying trends in the economy and have become an essential element in the toolkit of monetary and fiscal analysis in the past decades. In this working paper we approach the question of calculating potential output from a different angle: taking into account the dilemmas policymakers are facing when presented with uncertain estimates of this non-observable variable. Our objective is to construct more robust output gap estimates on a policy-relevant horizon mainly from a fiscal policy perspective. At the end, these estimates should help to improve the methodology to calculate structural budget balances.[4]

The role of structural budget balances (SB) in the conduct and evaluation of fiscal policy has gained on its importance in the recent past. Changes in both domestic and European fiscal frameworks put much more emphasis on calculating the underlying fiscal position and to specify medium-term objectives (MTO) in structural terms. While the concept is very appealing theoretically, real time evaluation of potential output and cyclically adjusted budget balances[5] is more an art than a science especially in small open economies with short history and many structural changes. It is a mystery like finding Yeti: only indirect evidence can be obtained at best, it is by definition unobservable.

Despite these well-known difficulties, according to the newly adopted "Fiscal Compact"[6], independent fiscal institutions should assess the deviation of actual outcomes from the MTO or the path toward it. Also, independent institutions should play an important role in triggering correction mechanisms.

Revisiting the output gap calculations in small and open economies is an important topic not only from a fiscal policy perspective, since policy makers often use this concept also in relation to monetary or structural policies.

The rest of the paper is organized as follows. The second section discusses different concepts of potential output and the output gap (OG). The third briefly summarizes the main methods of estimation. The fourth part evaluates real time estimates of OG for Slovakia. Our proposed methodology is presented in the fifth section. The last part contains proposals for further work.

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[4] It should be noted that there exist methods to calculate structural budget balances without the need to specify the output gap explicitly. However, in policy decisions under the SGP, the output gap is a crucial element.

[5] In a companion paper we present our proposed methodology for calculating structural budget balances in Slovakia (Marčanová and Ódor, 2014)

[6] Treaty on Stability, Coordination and Governance in the Economic and Monetary Union was signed on 2 March 2012 and entered into force on 1 January 2013.

2 DIFFERENT CONCEPTS OF POTENTIAL OUTPUT AND OUTPUT GAP

Measure of the output gap is an important prerequisite to calculate structural budget balances in many methods. Although widely used concept, there is no clear definition of the output gap, not mentioning the methodology to calculate it. In this paper we define potential output in a pragmatic way: *maximum level of output sustainable in the medium- to long-run*. **In other words, maintaining actual output at potential creates no imbalances in the economy of any sort (external, internal or financial).**

One can find many different concepts of potential output in the literature. Here we focus on three of them: a) statistical, b) Phillips curve concepts and c) "beyond-inflation" concepts.

The first category rests on very limited economic theory, if any. The main assumption is that there exists a business cycle with periods of booms and recessions. Therefore finding potential output means simply filtering out the relevant fluctuations from the data.

The second interpretation of potential output comes from the Phillips curve (PC) and refers to the maximum level of output without inflationary pressures. The original paper (Phillips, 1958) presented the well-known inverse relationship between the rate of change of wages and the level of unemployment in the UK between 1861 and 1957. Depending on the interpretation of the PC, one can generalize the idea from the labor market to the whole economy. As Congdon (2008) shows, the early interpretation of the Phillips curve led to the definition of the potential output in Keynesian tradition, implying only positive GNP gap[7]. Okun in his seminal paper (1962) defined potential GNP as a supply side concept corresponding to full employment. With the implicit assumption of constant inflation at *any* rate of unemployment, Okun tried to quantify how expansionary the fiscal policy should be to achieve full employment. Entirely different concept of output gap emerged from the Phillips curve after the criticism of the original relationship by Friedman (1968) and Phelps (1967). It led to the concept of natural rate of unemployment and non-accelerating inflation rate of unemployment (NAIRU). Later it was extended to the whole economy and resulted in a symmetric approach to the output gap (consistent with rising and falling inflation).

Phillips curve related concept of output gap is present also in the widespread use of DSGE models. Actually there are two concepts. The first is the flex-price output, the second is the efficient allocation output. The two can differ for example because of the distortions caused by the usual assumption of monopolistic competition in the standard New-Keynesian model. One can find in the literature first attempts to use these estimated DSGE models to calculate potential outputs (Galí et. al, 2005 or more recently Justiniano et. al, 2013).

When defining potential output, several researchers have started to look beyond the Phillips curve in recent years. They have noticed that relatively stable inflation and substantial fluctuations in output can coexist. Many other variables beyond inflation have been considered to better filter out underlying trends in the economy. Financial cycles (Benetrix

[7] Positive output gap meant at that time that actual output was almost always below potential.

and Lane, 2011 or Borio et. al, 2013), absorption cycles (Lendvai et. al, 2011) or commodity price cycles (Bornhorst et. al, 2011) are among the most discussed candidates.

In this paper we focus on all concepts of potential output highlighted above with the exception of DSGE model-based estimates, which are rarely used to calculate structural budget balances.

3 METHODS OF ESTIMATION

In this section we briefly introduce the most popular methods to calculate output gaps. We also highlight the main challenges in applying these methods.

3.1 CALCULATION OF OUTPUT GAPS

Potential output and the output gap are unobservable and model dependent. There exist a wide variety of methods to estimate output gaps. Each of them has its own information set, filtering technique and economic rationale.

The simplest approach is to use a single series (real GDP) and a well-known statistical filter to get the potential output. Among the most used techniques we can mention the Hodrick-Prescott filter (HP), Kalman filter (KF), band-pass filter, Christiano-Fitzgerald filter or the Beveridge-Nelson decomposition. The only additional information in these estimates is the relative importance of supply and demand shocks or the range of frequencies at which business cycles usually occur. One can find a nice overview of filtering techniques in Cerra and Saxena (2000). Here we focus on a short description of the most widely used Hodrick-Prescott filter, Multivariate Kalman filter, the production function approach and principal component analysis.

The HP-filter is a simple smoothing method, which isolates the trend component of a time series – in our case it divides real GDP data into trend (potential) output and the output gap. In addition, the procedure allows for flexibility of smoothness of the extracted trend. Denoting y as the level of real GDP, potential output y^* is obtained by

$$\min_{y^*} \sum_{t=1}^{T}(y_t - y_t^*)^2 + \lambda \sum_{t=2}^{T-1}[(y_{t+1}^* - y_t^*) - (y_t^* - y_{t-1}^*)]^2.$$

In other words, the HP-filter minimizes the sum of the squared gaps between the real GDP and its potential subject to a constraint that penalizes the squared differences in growth of trend output. The penalty parameter λ controls the smoothness of the trend: as λ becomes adequately large, the potential output approaches linear trend. If λ = 0, the formula forces the trend to adhere to original data. For this reason, the choice of parameter λ is crucial, since it indirectly affects the level of output gap. Real business cycle theory suggests, that the optimal value of λ depends on the ratio of variances of permanent (supply) and transitory (demand) shocks (King and Rebelo, 1989). But in practice, following Hodrick and Prescott (1997), λ = 1600 for quarterly data[8] has been introduced as the most common

[8] λ = 100 for annual data, λ = 14400 for monthly data, according to a formula that the number of periods per year divided by 4, raised to a power, and multiplied by 1600.

option. However, automatic setting of λ can lead to spurious, non-stationary output gap estimates with unreasonable smoothing of structural breaks. The second substantial shortcoming of the HP-filter is the so-called end-point problem. Since the filter is symmetric, estimates at the ends of the sample are always highly biased. The problem can be partially avoided by extending original data with forecasts, but a certain level of bias cannot be eliminated. Despite the noticeable drawbacks, estimating output gap with HP-filter is a relatively popular technique due to its simplicity.

Many researchers have tried to add more information to simple statistical filters usually through the Phillips curve. Multivariate HP filters (Laxton and Tetlow, 1992) or unobserved component models via the Kalman filter (see Konuki, 2008 for Slovakia) are good examples of this strategy.

State-space models, or multivariate dynamic models with unobserved components enable to incorporate economic theory into output gap estimation, providing better interpretability. The state space model combines the dynamics of observed, so-called "signal" variables ($n \times 1$ vector y_t) with those of unobserved, or "state" variables ($m \times 1$ vector α_t) in a following system:

$$y_t = c_t + Z_t \alpha_t + \epsilon_t$$

$$\alpha_{t+1} = d_t + T_t \alpha_t + v_t,$$

where c_t, Z_t, d_t and T_t are vectors and matrices, ϵ_t and v_t are serially independent normally distributed disturbances with zero mean and symmetric contemporaneous variance-covariance structure. Given the observed signal variables and the initial assumptions about state mean and variance values, the Kalman filter calculates one-step ahead estimate of state values and variance in a following way. First, from the state specification, it projects the state value and the error covariance ahead (prior estimate). Then, the state value is updated (posterior estimate), for most cases as a weighted average of the signal variable and the prior estimate of the state variable, giving more weight to a component with lower variance. In the second step, the error covariance is also corrected with the same weight as the prior estimate of the state variable. In the next iteration, the prior estimates are based on posterior estimates from the previous step. For details, one should refer for example to Harvey (1989).

In our context, to estimate output gap, the signal measurement variables are real GDP and inflation measures (entering GDP equation as the sum of potential output and output gap and the Phillips curve). On the other hand, unobserved state variables are potential output, output gap and a drift variable, included in the state equation of trend output as a control signal. Although Kalman filter is a powerful technique to estimate unobserved variables, in case of Slovakia as a relatively young country, its potential is to a great extent limited, mainly due to short history of data.

The single most used approach among international organizations (IMF, OECD or EC) is based on the aggregate production function. It is popular mainly because it allows explaining the changes in potential output in a very straightforward way; on the other hand it just translates the problems of filtering techniques to a lower level of aggregation.

The **production function** method is based on modelling economic factors that determine the potential output. The majority of empirical literature prefers the simplest form of the production function, the Cobb-Douglas formula:

$$Y_t = A_t K_t^{1-\alpha} L_t^{\alpha},$$

where Y_t is potential output, A_t is a trend-component of total factor productivity, K_t is capital, L_t is the trend component of available labour force (equilibrium employment) and α represents the labour's share of income. This parameter is calculated as an average ratio of wage costs and value added in the economy. Total factor productivity is the portion of output that is not explainable by capital and labour inputs and is computed as the Solow residual of capital and labour from real GDP. The trend-component of total factor productivity (derived by some filtering technique, e.g. HP-filter) than enters the potential output. Having time series for capital is rather a challenge even in advanced economies. It usually requires a construction of data from an initial value through new investments and capital depreciation. Finally, the equilibrium employment can be estimated either directly (e.g. using the HP-filter) or indirectly subtracting equilibrium unemployment (NAIRU, NAWRU or simple HP-filtered unemployment) from labour force.

In some cases **principal component analysis** of cyclical variables produced useful results (Pybus, 2011). A very intuitive way to get the picture of the economic cycle is to utilize information from variables that reflect its development. For this purpose, considerable potential is contained in soft indicators obtained from business or consumer surveys, labour market variables or financial indicators. Principal component analysis (PCA) provides a standard technique to extract the essence of cyclical indicators, which can be considered as the output gap.

PCA is a mathematical procedure that converts a set of possibly correlated variables into a set of orthogonal, linearly uncorrelated variables called principal components. At the same time, principal components always account for as much of the remaining variability in the data as possible, so they are ordered as from having the largest possible variance to the smallest one.

Output gap can be defined as the first principal component of the cyclical indicators. This method avoids the problem of data revisions, since the history of applied data is fully unchanging (with the exception of seasonally-adjusted data). Moreover, the method estimates the output gap itself and there is no need to subtract potential output from GDP, which is often subject to revisions.

PCA is however sensitive to the relative scaling of the original variables. Therefore, prior to processing the analysis, it is necessary to standardize the variables so that to have data in comparable units of measurement. On the other hand, the procedure produces an output gap series with zero mean and unit variance, so to have output gap in real measures, the output gap series obtained from PCA is necessary to rescale (usually via statistics of the HP-filtered output gap).

Further, structural VAR models or fully-fledged macro models are also used for calculating output gaps.

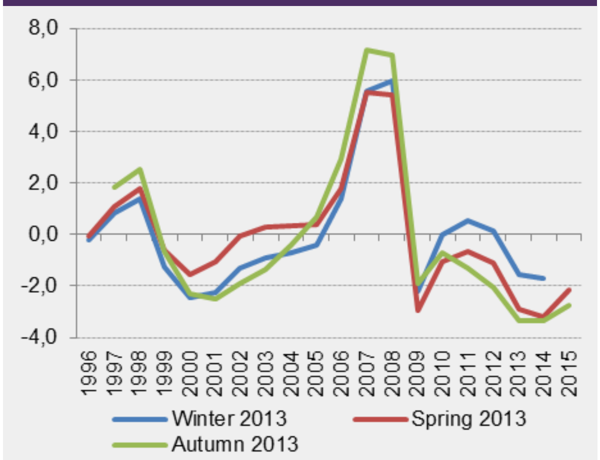
3.2 MAIN CHALLENGES IN APPLYING THE CURRENT BENCHMARK METHODOLOGY

As Ódor (2011) shows, estimating output gaps in small and open economies is a challenging task. The current benchmark method in Europe (Larch and Turrini, 2009 and Mourre et al. 2013) based on the production function approach has in our view a lot of shortcomings in small and open economies:

- short-time series to estimate long-term trends with many structural breaks,
- high uncertainty around capital stock estimates,
- downplaying international capital and labor mobility,
- size of current account imbalances and banking sectors relative to GDP can be important in small and open economies,
- frequent supply side shocks,
- end-point problem of the HP-filter.

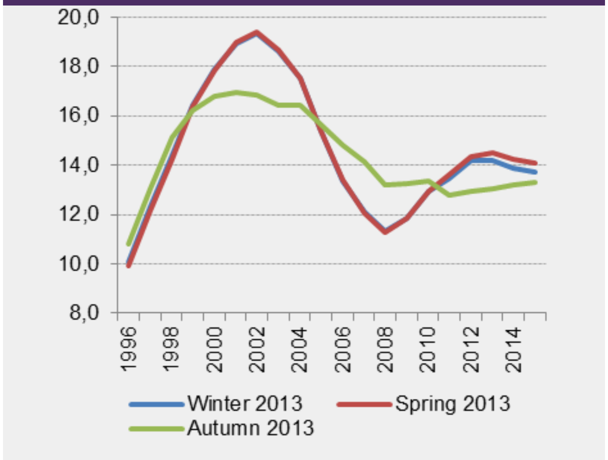
Frequent and substantial revisions of potential output estimates are rather the rule not the exception. Figures 1 and 2 show the last three vintages of European Commission´s forecast for Slovakia (Winter, Spring and Autumn 2013 estimates).

Figure 1 – Output gap in Slovakia (EC estimates)



Source: EC

Figure 2 – NAWRU in Slovakia (%) – EC estimates



Source: EC

All three vintages are based basically on the same – commonly agreed - production function methodology. For 2011 the three output gap estimates are +0.5, -0.6 and -1.3 respectively. In case of the last year (2012) we get similar picture with estimates ranging from +0.1 to -2.1. One can spot substantial differences also in the NAWRU estimates. It is important to note that in this case the main differences in outcomes are **due to technical factors**, which are hard to explain to policymakers and the general public:

- between the winter and spring vintages: TFP trend filtering changed from HP filter to Kalman filter,
- between the spring and autumn vintages: changes in upper bands for trend and cycle innovation variances in NAWRU estimation.

More detailed evaluation of real-time estimates is described in the next section.

Unfortunately the list of shortcomings is similarly long for the other methods, therefore in our view the best way forward is to calculate more robust estimates of output gap via forecast combination. Ideally policy-makers would like to have estimates of output gap which are stable, informative and can be framed in a coherent framework. As we show later, the current benchmark is not stable, neither informative, but at least easily understandable. In our view it is time to score higher in the first two dimensions at the expense of the third one. By combining various estimates with different information sets we aim for more stable and more informative estimates of potential output.

4 EVALUATION OF REAL TIME ESTIMATES FOR SLOVAKIA

In this section we illustrate the difficulty to calculate potential output in Slovakia in real time.

4.1 REAL TIME ESTIMATES OF OUTPUT GAP

First we created a database containing all the vintages of quarterly real GDP (and other relevant variables) available in real-time from 2002 onward (starting with the first quarter in 1995[9]). To allow comparison with the estimates of domestic and international organizations, we run the models on datasets ending in second (available in autumn) and fourth (available in spring) quarters. We employed 4 methods on real-time data and compared the results with the estimates of the European Commission, National Bank of Slovakia (NBS) and the Ministry of Finance (MoF)[10].

SHPQ – the simplest benchmark is the well-known Hodrick-Prescott filter. The estimation contained no forecast to augment the GDP series and was carried out on quarterly data with a standard parameter 1600 (lambda). We also experimented with annual data (where the

[9] The first two years of the existence of Slovakia (1993-1994) showed significant structural and methodological changes, so we dropped these data from our database (with the exception of soft indicators).

[10] One should note that there could be small differences in datasets available to these institutions since their forecasts were not released at exactly the same date.

forecasts of the NBS are available to augment the HP-filter), however the real-time performance compared to the simple quarterly HP-filter was not better.

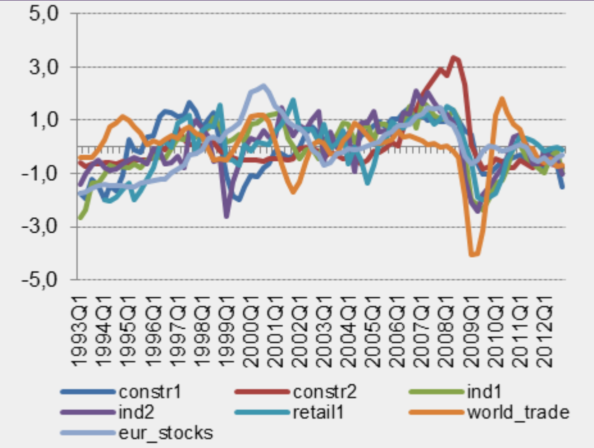
MVKF – To ease the end-point problem of the HP-filter and to use more information from economic data, we constructed a simple state-space model and estimated it via the multivariate Kalman filter. Following IFP (2010), we used two measurement equations: one for the GDP and one for the Phillips curve (PC). The PC is modeled (similarly to IFP) using lagged inflation[11], lead inflation, regulated prices (to capture the indirect effects of administrative price changes) and the output gap. The trend GDP is a random walk with drift, which itself is a random walk. The cyclical component is a simple AR (2) process. The initial parameter values were set based on an HP-filter estimate of the output gap and OLS estimate of the Phillips curve. We used the Berndt-Hall-Hall-Hausman optimization algorithm. Unfortunately the process (to achieve convergence) was very sensitive to the choice of the initial state vector. In appendix 1 there is a comparison of HP filter and MVKF estimates for several vintages.

PCAG – principal component analysis (PCA) is a popular method to extract common cyclical fluctuations from data. Among independent fiscal institutions the Office for Budget Responsibility (Pybus, 2011) uses this methodology to calculate output gaps. The main advantage is that the times series used (soft indicators or financial variables) are usually not subject to data revisions. The disadvantage is that it is not clear how to select variables for the analysis and the result is sensitive to the de-standardization procedure[12]. Some of the time series from business surveys are available from 1993 onward based on the same methodology. We tried many variables (see Annex 2) but similarly to OBR we found a small subset of indicators responsible for the bulk of fluctuations. Therefore we used a simple 7-variable PCA for evaluation purposes. Unfortunately there is no long time series for the service sector and for the financial cycle to incorporate them in the analysis. Figure 3 shows the evolution of selected variables for the PCA analysis. For illustration purposes, figure 4 shows the different vintages of EC estimates compared to the last vintage of PCA analysis.

[11] More precisely net inflation, which excludes food and energy prices and also regulated prices.

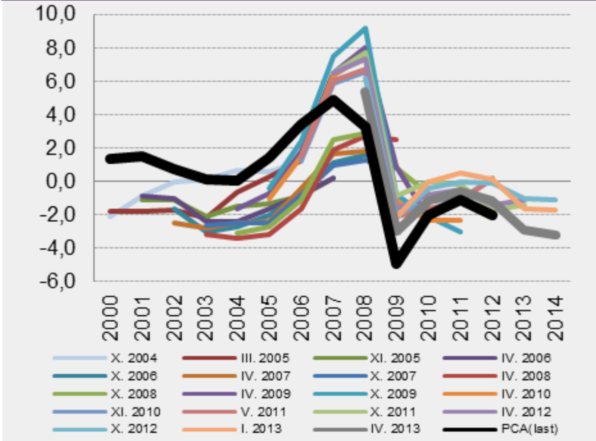
[12] The PCA analysis results in a time series with zero mean and unit variance.

Figure 3 – Variables for PCA analysis (normalized, last vintage)



Source: SOSR, CPB World Trade Monitor, STOXX

Figure 4 – EC estimates of output gap and PCA final vintage

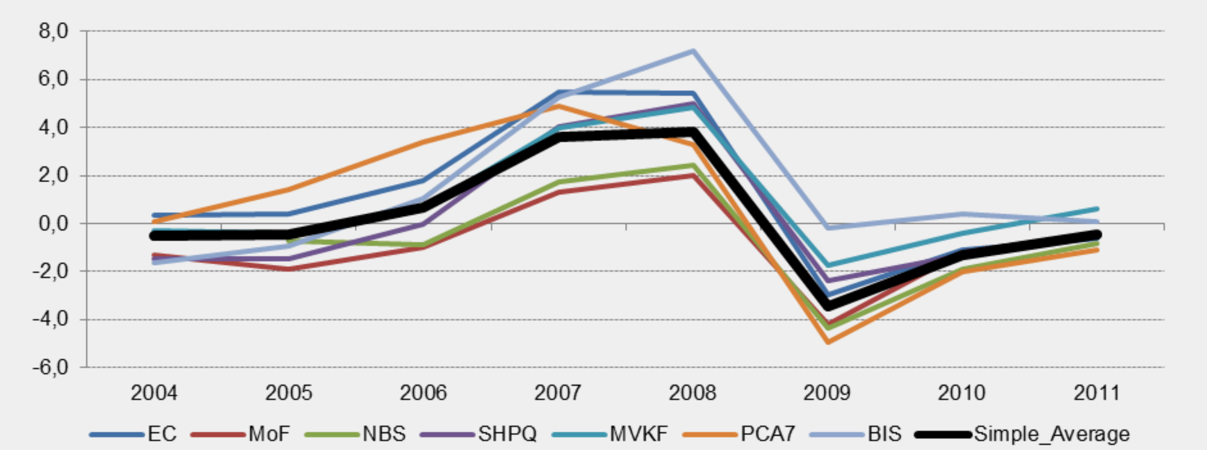


Source: authors, EC

BIS – Borio et. al (2013) try "to capture the information content that financial factors have for the cyclical, potentially highly persistent, variations in output." They estimate "finance-neutral" measure of potential output by employing the Kalman filter on a model where mean-adjusted financial variables can have effect on the cyclical component of output. Since financial cycles are longer than business cycles, the length of Slovak time series was a serious constraint. Despite the fact, that we consider this methodology as promising from a theoretical point of view, we were not able to obtain statistically significant coefficients on real-time data. In appendix 3 we therefore report only the results for the last vintage of data.

The 3 other estimates are from the EC, NBS and MoF. The methodology of the EC and MoF is based on the production function approach (MoF methodology in Galabová et al, 2005), while the NBS uses a small-scale gap model to calculate output gaps (Gylánik and Hušek, 2009). Obviously, these estimates are not simple mechanical outputs from models; they were combined with expert judgments. Figure 5 shows the last vintage of estimates from all 7 methodologies.

Figure 5 – Different methods to calculate output gaps in Slovakia (last vintage)



Source: SOSR, EC, MoF, NBS, authors

It is easy to spot that there are substantial differences between the methodologies, since potential output is model dependent and the data sets used have very different information content (in some cases also expert judgments – EC, NBS, MoF). In the next part of this section we evaluate the real-time performance of these methods (except of the BIS, where only the last vintage is available).

4.2 EVALUATION OF RESULTS

The interesting question is: what should be the loss function of policy makers or the independent fiscal institutions (IFIs)? One aspect is stability in our view. To maintain credibility, big changes between different vintages of estimates should be avoided, mainly in a short-term horizon (up to one year[13]) and especially for technical reasons. Second important aspect is plausibility. There is no point in publishing the same number every half year if it is at odds with other important macroeconomic and financial variables.

In our simple evaluation exercise we selected four measures to compare the different methods:

i) AS[14] – absolute difference between the estimate for year t in autumn t+1 compared to spring t+1; in other words the difference between the first two estimates available after the completion of year t when deviation from the MTO can trigger correction mechanisms

ii) SS – absolute difference between the estimate for year t in spring t+2 compared to spring t+1

iii) LS – absolute difference between the estimate for year t in the last vintage compared to spring t+1; in other words difference between the very last and very first vintage after the completion of year t

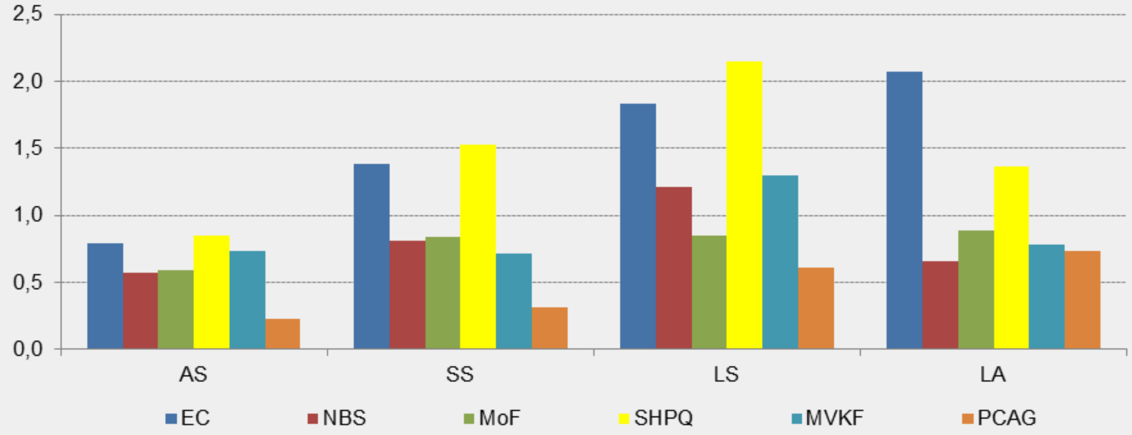
iv) LA– absolute difference between the estimate for year t in the last vintage compared to autumn t+1

Comparison of estimates during one-year (from spring t+1 to spring t+2) is important because of credibility, while differences between first estimates and the last vintage are more about changes in views over time, when more data points are available. Figure 6 illustrates the average value for these four statistics for the output gap estimates. Before commenting the results one should note that only 8 years are available to calculate these statistics (2004-2011).

[13] The significant deviation from MTO is defined 0.5 percent in one year or 0.25 percentage on average for two years. For this reason one would want relatively stable and informative estimates at least on a one year horizon.

[14] A=autumn, S=spring, L=last

Figure 6 – Evaluation of real-time output gap estimates based on simple statistics (% of GDP)



Source: SOSR, EC, NBS, MoF, authors

The results are quite interesting. The average absolute difference in 6-month time (between spring and autumn forecast for the same year) is the highest for the simple HP-filter (0.85 percentage points of GDP) and for the estimates of the European Commission (0.81 pp). The estimates of the MoF and NBS change on average by almost 0.6 pp, while the PCA analysis is the most stable with 0.22 pp.

On a one-year horizon (between spring t+1 and t+2) the most volatile is again the HP-filter together with the EC (1.3-1.5 pp). Other methods are much more stable around 0.7 and 0.8 percentage points.

The average differences between the very first and the last estimates for year t are again very high for the EC and the HP-filter. In all aspects the PCA is the least volatile methodology. On the one hand it is understandable, since there are no revisions to data, on the other hand the data are limited to 3 domestic sectors only (industry, construction and trade), thus restricting the information content of the results.

The average statistics (simple average of the four statistics) is the worst for the EC forecasts (1.5 pp) and the HP-filter (1.47 pp). The estimates of the MoF and NBS are qualitatively similar at 0.8 pp. The Kalman filter produces 0.88, while the PCA 0.47 pp.

5 Simple methodology for more robust estimates

We agree that fiscal rules at the EU level require a common methodology to calculate output gaps accepted by all countries. However making figures comparable across countries is clearly not the best alternative if the focus is on domestic rules. One-size-fits-all methodology is usually a compromise, actually resulting in one-size-fits-none. Since international comparability is not a constraint, we wanted to be as pragmatic as possible, while taking into account the specificities of the Slovak economy.

Slovakia is a small open economy with very short history, many structural breaks and changes in methodologies concerning the relevant data. There are no reliable data about capital stock and supply shocks are important. In this environment the task to calculate potential output is even harder than in more developed economies with long time series. Models developed and calibrated to do well on advanced economy data are unlikely to provide a reliable assessment of the cyclical position of a small open economy undergoing convergence[15].

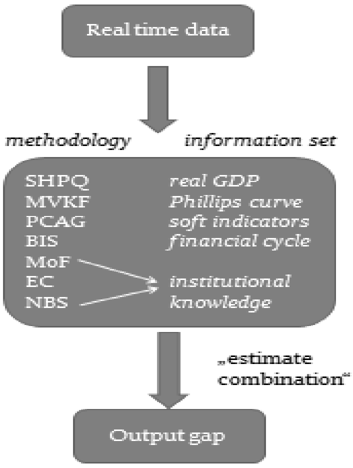
Our approach is based on experiences from the forecast combination literature. As we have seen earlier, the current production function methodology of the EC is characterized by substantial revisions and hence little information content. On the other hand it is theoretically coherent and easy to explain to the public and horizontally consistent across countries, which is important from a political point of view. Our objective is to have a more stable and informative estimate even at the cost of doing worse on the dimension of consistency with theory. We do not have to worry about cross-country consistency.

Of course, ideally one would want a model-based estimate of potential output to have a "preferred narrative". We consider the BIS methodology or more complex DSGE model based estimates as promising, however the application of these theoretically more sound approaches in Slovakia is plagued with many problems. Therefore we have decided to bridge the gap between current methods and future model-based estimates with "estimate combination".

As Timmermann (2006) notes, when multiple forecasts of the same variable are available to decision makers, forecast combinations offer diversification gains. If individual forecasts are differently affected by structural breaks, have a misspecification bias of unknown form or the underlying forecasts are based on different loss functions, it is useful to apply forecast combination. It is to some extent surprising that in the literature simple combinations that ignore correlations between forecast errors often dominate more refined schemes in out of sample performance.

[15] Recall from the previous section the performance of the European Commission output gap estimate based on the EU-wide commonly agreed methodology.

Figure 7 – CBR´s methodology



Estimation of the output gap for the previous years is not a forecast. On the other hand, the problem has some similarities with forecasting. Different methods are available with different information sets (public and private) and based on different loss functions. Moreover the variable is not observable, so substantial backward revisions are common. For the policy maker it is hard to deal with the huge uncertainty in the estimation. In our view policy makers need more robust estimates based on simple portfolio diversification argument.

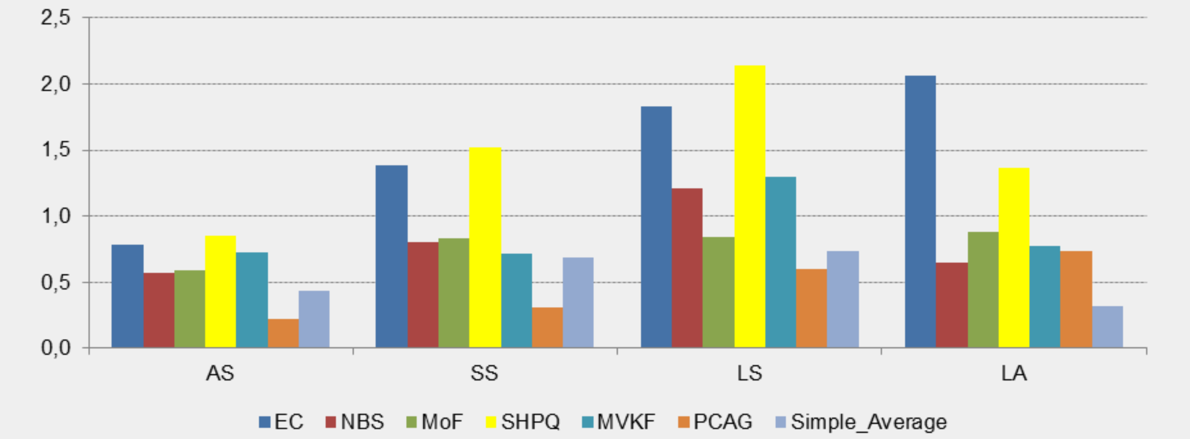
Figure 7 illustrates our proposed methodology for countries like Slovakia, where fully-fledged models based on sound theory are hard to implement due to data constraints. The basic idea is to combine different methods and information sets to get more robust estimates. While in analytical works this approach is inferior, for policy-making purposes it might deliver better outcomes.

As we are going to show, without using a more sophisticated combination technique, the simple average output gap significantly reduces the volatility of updates on a policy-relevant horizon compared to the current benchmark methodology (EC).

In the first phase we have decided to calculate a simple average of the seven real time estimates[16] presented in section 4.1. The idea is that this way we can combine information from soft indicators, real economy variables, inflation, financial variables and analysts' judgments while decreasing the volatility of the estimates. Figure 8 shows the results.

[16] To compare this measure with other methodologies, we dropped BIS from the sample, since only one vintage is available.

Figure 8 – Real-time evaluation of the simple average output gap (% of GDP)



Source: SOSR, EC, NBS, MoF, authors

This way we were able to substantially reduce the average absolute differences compared to the EC method. The average of the four statistics for the EC was 1.5 pp. while for the combined estimate (simple average) only 0.55 percentage points of GDP.

It is also informative to look at real-time estimates in spring 2009 and spring 2010 to see the performance not in average but just before and shortly after the outbreak of the crisis. As Table 1 shows the EC grossly overestimated the output gap just before the crisis, while it seems that the Ministry of Finance consistently underestimates it (compared to other methods)[17]. The best performer was the principal component analysis, while the combined estimate finished second. The picture for 2009 reveals that the magnitude of the recession was initially underestimated by the EC and overestimated by the NBS. It is interesting that the PCAG showed also substantial revisions probably because the first reaction of managers to the crisis was very pessimistic.

[17] It makes sense that during boom period there is a motivation to show lower positive output gaps, while in recession more negative ones to get more favorable estimates of structural budget balances.

Table 1 – Evaluation of methods for output gap in crisis times (real-time)

Method	Spring 2009		Spring 2013		Difference (S13-S09)	
	2007	2008	2007	2008	2007	2008
EC	6.5	8.0	5.5	5.4	-1.0	-2.6
MoF	1.5	1.7	1.3	2.0	-0.2	0.3
NBS	0.7	0.6	1.8	2.4	1.0	1.9
SHPQ	1.3	0.9	4.1	5.0	2.8	4.2
MVKF	2.6	2.1	4.0	4.9	1.4	2.8
PCAG	3.4	2.4	4.9	3.3	1.5	0.9
SIMPLE_AVERAGE	2.7	2.6	3.6	3.8	0.9	1.2

Method	Spring 2010	Spring 2013	Difference (S13-S10)
	2009	2009	2009
EC	-1.2	-3.0	-1.8
MoF	-3.8	-4.2	-0.4
NBS	-7.7	-4.4	3.3
SHPQ	-4.5	-2.4	2.2
MVKF	-1.9	-1.8	0.1
PCAG	-4.9	-5.0	-0.1
SIMPLE_AVERAGE	-4.0	-3.4	0.6

Source: authors

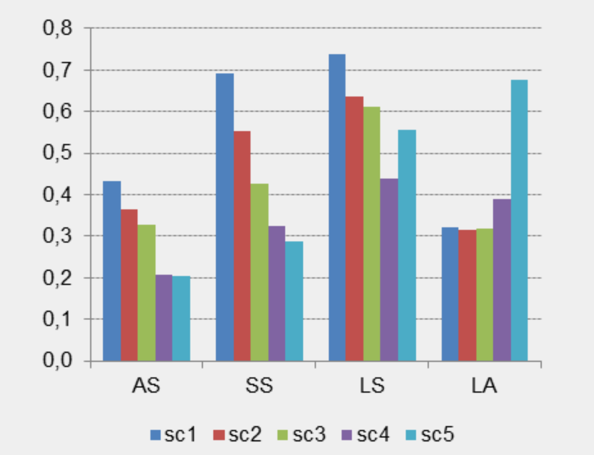
From the above comparisons, the PCAG and the combined methodology come out as good candidates for real time output gap estimation. We have decided to work with the combined estimate since services and financial cycles are not included in the principal component analysis and at the end it is always possible to attach more weight in the combination to the PCAG.

The next two figures illustrate 5 different scenarios using different weights:

- sc1 is the benchmark case with simple average of all methods
- sc2 is a weighted average of all methods based on their performance with regard our simple statistics
- sc3 is the same as sc2 however the 2 worst performers (EC and HP filter) are not included
- sc4 is a weighted average between PCA (75%) and NBS (25%) methods
- sc5 is the PCA only

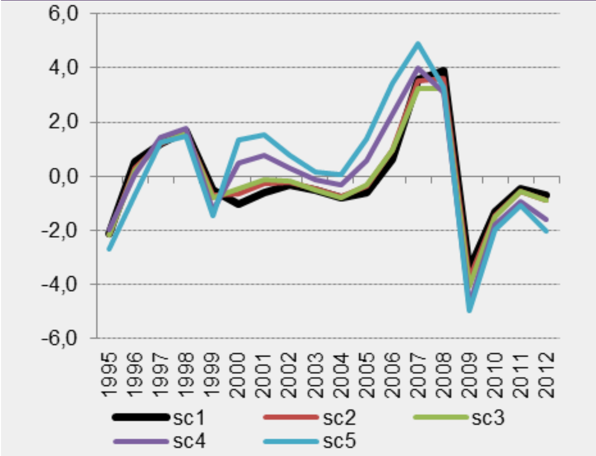
The PCAG alone gives the most stable estimates in the short-run, however it probably overestimates the output gap in periods where the domestic demand was depressed in early 2000s (since services are not included). As far as the comparison with the last vintage is concerned, other weighting schemes perform better than the PCAG alone.

Figure 9 – Performance of five different weighting schemes



Source: authors

Figure 10 – Last vintage from different weighting schemes



Source: authors

Since there are no substantial differences between the individual weighting schemes, we have decided to stick to the simple average. We need more data points to give higher weight to systematically unreliable estimate techniques.

6 CONCLUSIONS AND FURTHER WORK

The objective of this working paper was to emphasize two points:

First, there are trade-offs between model-based and theoretically consistent estimates of potential output and more robust but ad-hoc estimates of output gap from a perspective of a policymaker or an independent fiscal institution. When credibility and possible welfare implications are at stake and model-based estimates are imprecise and very volatile, it makes sense to combine various methods and information sets to make better decisions. This is important after the adoption of the Fiscal Compact, which requires real time numerical evaluation of structural budget balances on a yearly basis and not on average or "over the cycle".

Second, one-size-fits-all methodologies in a diverse economic union are actually one-size-fits-none approaches. Therefore independent fiscal institutions should in our view adopt country- specific and tailor-made methodologies.

We have illustrated that by combination of estimates in real time one can substantially reduce the uncertainty of output gap figures for Slovakia on a policy-relevant horizon. In the future we would like to focus on several interesting questions:

- Asymmetric loss functions of policy makers/IFIs. Since there is a threshold for launching correction mechanisms from a welfare perspective it is different to have false positives than false negatives. In other words, it is more costly to activate the correction mechanism in case of no substantial deviation than not to activate it (or activate it later) when there is in fact a significant deviation.

- More sophisticated estimate combination (possible principal component extraction or time varying weights). Despite the surprising fact from the forecast combination literature that simple averages have generally better out-of-sample performance than more sophisticated methods, we would like to explore further assigning different weights to different methods based on some measure of past performance.

- Careful selection of individual estimates. There are two important questions. First, for policy evaluation purposes it is maybe not ideal to assign high weight to Ministry of Finance estimates. Second, it might be worthwhile to add more model-based estimates (even including DSGE) or to drop some of the most mechanical filtering techniques.

- Financial cycles and the BIS methodology. Generally speaking a lot more resources should be devoted in Slovakia to study the beyond-inflation concept of output gap. It can be useful in the future, since the nominal convergence process will imply higher inflation and lower real interest rates in the future for Slovakia. If that happens, credit cycles might mask the underlying budgetary position.

- Potential bias in estimates. Some estimates included in the analysis can be biased, especially those of the authorities. We would like to look at and evaluate past revisions from this perspective. In case of systematic bias (usually overestimation of potential output) it can make sense to use an "asymmetric" approach by creating reserves for negative surprises at the cost of pro-cyclical policy at some occasions.

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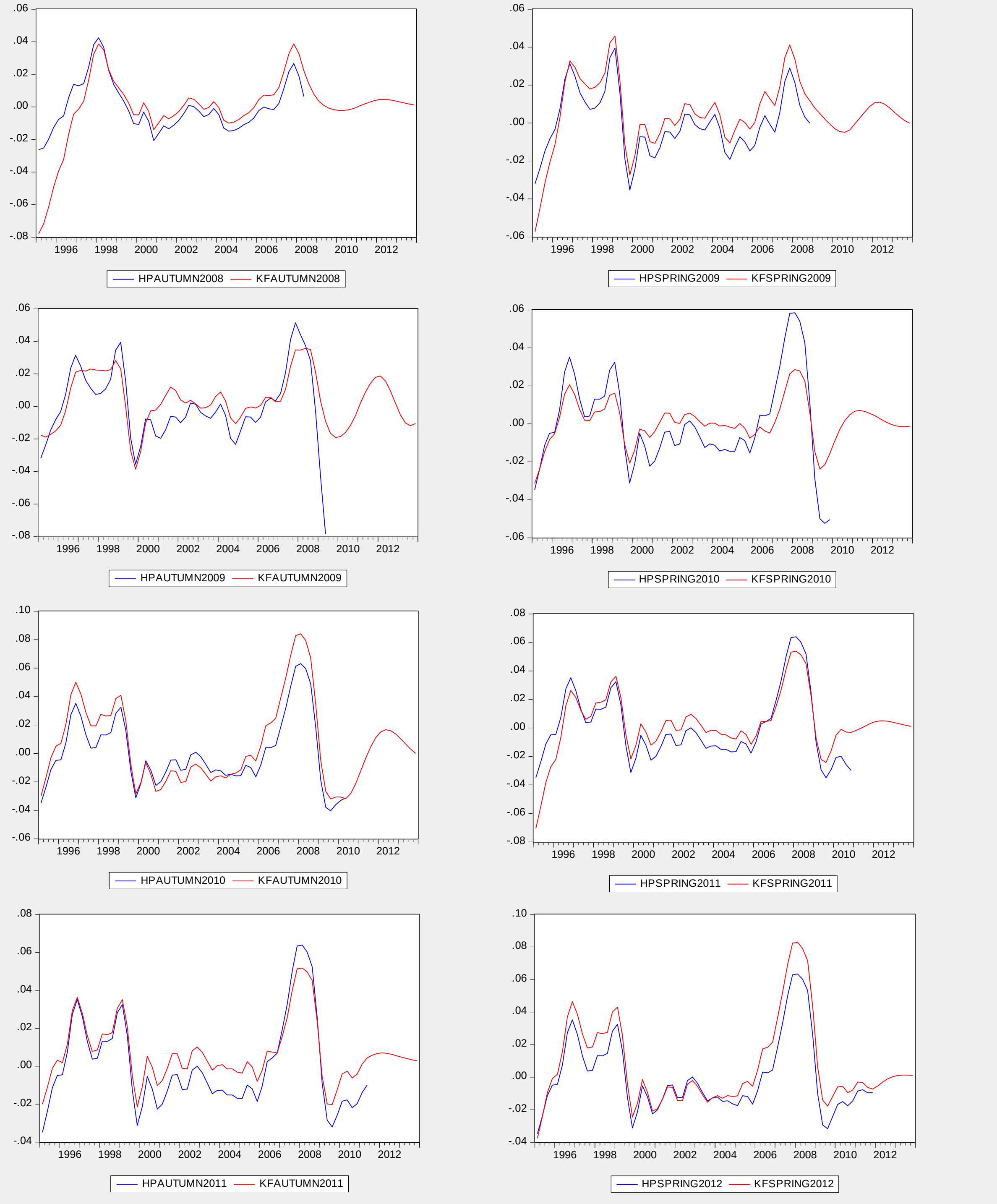
ANNEX 1 – COMPARISON OF THE MULTIVARIATE KALMAN FILTER AND HP FILTER

Figure 11 – Differences between SHPQ and MVKF estimates



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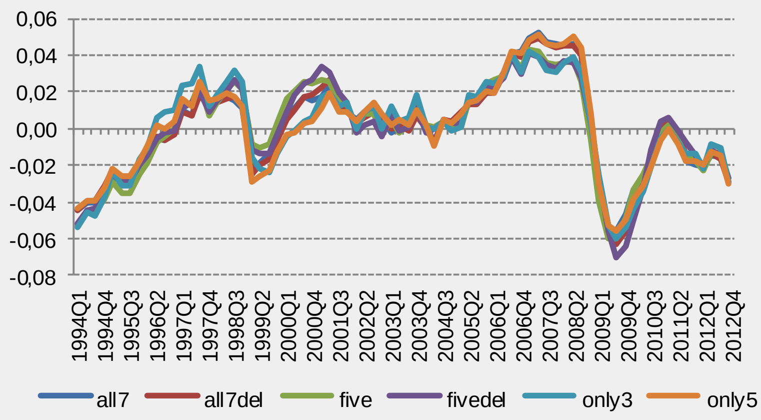
ANNEX 2 – DETAILS OF THE PRINCIPAL COMPONENT ANALYSIS

We considered the following variables to include into PCA: Slovak survey indicators as detailed components of consumer, industrial, construction, retail trade and services confidence and index of business environment. In addition, we also tried German survey indicators as 6-months lagged ZEW indicator of economic sentiment and 3-months lagged IFO business climate index, world trade indicator and stock market indices. Further, from labour market employment, unemployment in persons, disposable persons and unemployment rate, nominal wages and real wages growth. Finally, we took 3m Bribor/Euribor rate and credit to households into consideration. Together nearly 130 data series, however, we substantially reduced the number of indicators entering the analysis at the end, because of insufficient observations (many variables are available only from the early 2000´s) or low weight coefficients in PCA.

The final model contains 7 variables, from which 5 are survey indicators of confidence in Slovakia: order books in construction, shortage of labour force in construction, capacity utilization in industry, order books in industry and trade business activity. The remaining 2 variables are: year-on-year growth of world trade volume and the Euro STOXX 50 equity index. We processed seasonal adjustment and standardization of input data and a subsequent de-standardization of output gap according to a benchmark HP-filtered output gap for every single vintage distinctly (data cover the period 1Q1993 - 1Q2013, first vintage ends in 4Q2002).

Figure 12 – Different PCA candidates (output gap)



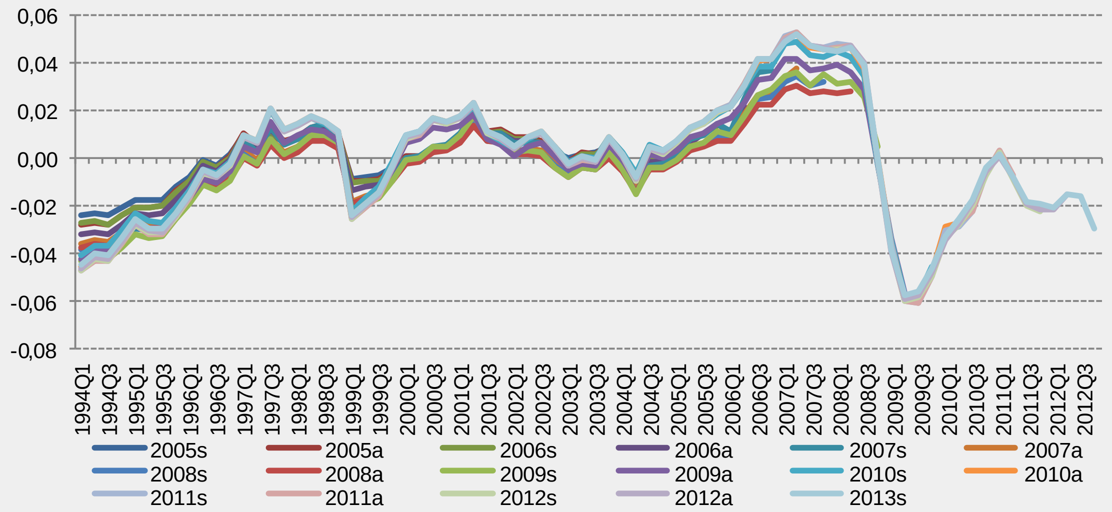
Source: authors

Figure 12 shows the last vintage for 6 potential candidates. They are all very similar:

- all7 includes all 7 above mentioned indicators
- all7del is the same as all7 with lagged world trade and Eurostoxx 50 variables to reflect their role as leading indicators
- five is a combination of 3 domestic and 2 external indicators
- fivedel is the same as five with lagged external variables
- only5 is a variant when only domestic indicators were included
- only3 contains only 3 domestic indicators – one from each sector

As one can see from the above figure, the main difference between the different candidates is the estimated output gap in the period 1999-2000. It is the era of significant domestic austerity measures and subsequent reforms. It is unlikely that the negative output gap in 1999 was very small and in 2000 significantly positive. We have therefore decided to use 7 indicators, since in case 5, the external factors clearly dominate. This is exactly one of the main weaknesses of PCA analysis that the initial choice of variable is important. While there was no big difference between the versions with contemporaneous and lagged external variables, we have decided to use the all7 variant.

Figure 13 – Different PCA vintages



Source: authors

Table 2 contains the results of the principal component analysis for the last vintage (all7, spring 2013). The first principal component was able to explain more than 50% of variations in the data.

Table 2 –PCA results

1. principal component eigenvectors(loadings):		**Ordinary correlations**							
			const1	const2	indi1	indi2	retail1	world_trade	eur_stocks
const1	**0,35**	const1	**1**						
const2	**0,37**	const2	**0,57**	**1**					
ind1	**0,47**	ind1	**0,45**	**0,49**	**1**				
ind2	**0,44**	ind2	**0,53**	**0,47**	**0,73**	**1**			
retail1	**0,44**	retail1	**0,57**	**0,52**	**0,69**	**0,59**	**1**		
world_trade	**0,13**	world_trade	**0,03**	**-0,7**	**0,38**	**0,34**	**-0,01**	**1**	
eur_stocks	**0,34**	eur_stocks	**0,03**	**0,33**	**0,64**	**0,5**	**0,53**	**0,06**	**1**

Source : CBR

ANNEX 3 – FINANCIAL CYCLES AND THE OUTPUT GAP IN SLOVAKIA

Researchers at the BIS investigated the role of financial cycles for the output gap estimation (Borio et al, 2013). According to them there is a conceptual problem with the definition and measurement of the output gap. They argue that output may be on an unsustainable path even if inflation is low. By including financial cycles into the analysis Borio et. al were able to improve the precision of output gap estimates. Moreover the results were more robust in real-time.

Despite the drawback of short time series in Slovakia, we followed their approach to find out the role of financial cycles[18]. The basic set-up is the following state-space representation:

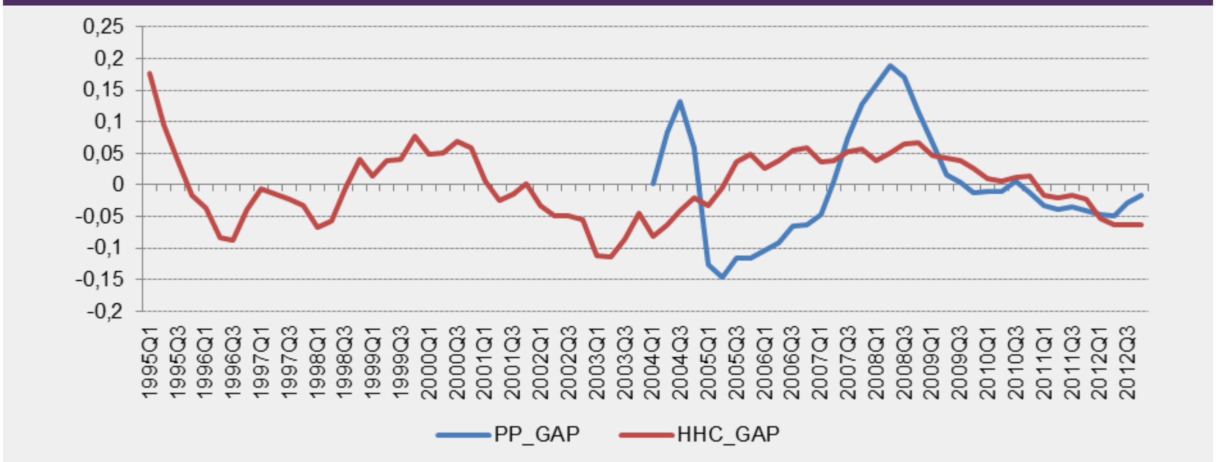
$$\Delta y_t^* = \Delta y_{t-1}^* + \varepsilon_{0,t}$$

$$y_t - y_t^* = \gamma' x_t + \varepsilon_{2,t}$$

where y_t is the log output, x_t is a vector of economic (financial) variables. When estimating the measurement equation, standard estimators assign a zero weight to any information in x_t that does not help to explain business cycle fluctuations. Borio et. al (2013) include private sector credit and property prices into their final specification.

We tried the following variables: private sector credit, credit to households, unemployment, real interest rate, property prices, current account, real-exchange rate and inflation. Our benchmark specification is the following. We included 4 variables in x_t: credit to households, property prices, unemployment and inflation. Figure 14 illustrates HP-filtered gaps in household credits and property prices.

Figure 14 – Financial cycles in Slovakia



Source: authors

[18] We thank Piti Disyatat for sharing the basic Matlab code with us.

The property price gap is distorted by the speculation bubble just before the entry into the EU. Among variables household credit and unemployment were significant at 10% level. The other two were not significant. Figure 15 highlights the finance neutral output gap based on the BIS methodology. Despite being promising avenue for research, this method can currently play only supplementary role because of the problems with short time series and estimation.

Figure 15 – Finance neutral output gap in Slovakia

Source: authors

ANNEX 4 – DATA SOURCES

Variable	Short description	Source	Period
GDP	Gross domestic product, National Accounts, constant prices, mil. Eur, quarterly, NSA; real-time vintage series	SOoSR	1Q1995-1Q2013
GDP	Gross domestic product, National Accounts, constant prices, mil. Eur, annual, NSA; real-time vintage series	SOoSR	1995-2012
const1	Order books in construction confidence indicator, index, Business Tendency Surveys, monthly, NSA	SOoSR	1M1993-3M2013
const2	Shortage of labour force in construction confidence indicator, index, Business Tendency Surveys, monthly, SA	SOoSR	1M1993-3M2013
ind1	Capacity utilization in industrial confidence indicator, index, Business Tendency Surveys, quarterly, SA	SOoSR	1Q1993-1Q2013
ind2	Order books in industrial confidence indicator, index, Business Tendency Surveys, monthly, NSA	SOoSR	1M1993-3M2013
retail1	Business activity in retail trade confidence indicator, index, Business Tendency Surveys, monthly, NSA	SOoSR	1M1994-3M2013
world_trade	Merchandise world trade volumes, index 2005=100, monthly, SA	CPB World Trade Monitor	1M1994-3M2013
eur_stoxx	Euro STOXX 50 Index, values in EUR, daily,NSA	STOXX	3.1.1994-28.3.2013
private sector credit	Loans to private companies, mil. EUR , monthly, NSA	NBS	1M1994-12M2012
credit to households	Loans to households, mil. EUR, monthly, NSA	NBS	1M1994-12M2012
real interest rate	Nominal 3M interest rate/cpi, index 1Q 1993=100, quarterly, NSA	NBS	1Q1993-1Q2013

property prices	Residential property prices total, EUR/m2, quarterly, NSA,	NBS	1Q2005-4Q2012
CA	Current account – balance, mil. Eur, quarterly, NSA	NBS	1Q1993-1Q2013
REER	real exchange rate based on ppi, index 1Q1993=100, quarterly, NSA	NBS	1Q1993-1Q2013
inflation	Consumer price index Dec 2000=100, quarterly, NSA	SOoSR, NBS	1Q1997-1Q2013
net inflation	Net inflation excluding fuels (without Influence of indirect taxes changes in non-regulated prices), consumer price index Dec 2000=100, quarterly, NSA	NBS	1Q1997-1Q2013
regulated prices	Regulated prices, consumer price index Dec 2000=100, quarterly, NSA	SOoSR, NBS	1Q1997-1Q2013
Output gap - EC	Output gap as % of potential output, European Economic Forecast, annual; real-time vintage series	DG EcFin, EC	2000-2011, first vintage in autumn 2004
Output gap - NBS	Output gap as % of potential output, National bank of Slovakia Medium Term Forecast, annual; real-time vintage series	NBS	2003-2012, first vintage in spring 2005
Output gap - MoF	Output gap as % of potential output, Convergence and Stability Programmes, annual; real-time vintage series	MF SR	2001-2012, first vintage in spring 2004