ANNEX 2. Potential output in Lithuania – a joint measure using real and financial sector variables

1. The complex nature of potential output estimation

Potential output is generally defined as “the maximum production without inflationary pressure – or more precisely – the point of balance between more output and greater stability” (Okun, 1970). An associated measure is the output gap, defined as the difference between actual and potential output. Considering economic policy applications of these concepts, when the output gap is positive (actual output is greater than potential output), there is upward pressure on inflation; similarly, disinflation requires actual output to fall below potential output. This relationship, therefore, provides implications for the conduct of stabilising policies. The output gap is also of central importance to fiscal policy surveillance as it is an essential input in the calculation of the cyclical component of the general government balance (see, e.g., Angerer (2014)). Recently, the output gap has started playing an increasing role in the operation of macro-prudential policy. Despite the relevance of these concepts to economic policy, the main challenge in the application of potential output is the inability to directly observe it. Consequently, policy makers need to rely on imperfect measures of its level and dynamics.

The widely used Hodrick-Prescott filter is appealing due to its simplicity and transparency, requiring only GDP data. Its main drawback is the lack of economic structure, particularly links to inflation and the unemployment rate. These important theoretical concepts are needed to allow us to check the validity of the derived measure against labour market and inflation dynamics. Another widely used method is to rely on a production function approach, formulating a structural relationship between production inputs (capital and labour) and output. Nevertheless, reliable capital-stock data can be hard to obtain. In addition, constructing the cyclical-adjusted measures of inputs, i.e. total factor production and employment components, is an onerous task. In practice, they are often constructed based on ad hoc trend-cycle decompositions, such as the HP filter, which are, therefore, subject to the weaknesses mentioned above. The third approach for estimating potential output, which is used in this annex, is a semi-structural time series framework. This method is also known as a multivariate unobserved component (MUC) model which was first proposed by Kuttner (1994) and has been developed and applied in recent studies, including Benes et al. (2010), Blagrave et al. (2015), Alichi et al. (2015) and Melolinka and Tóth (2016), among others.

In our baseline, we model potential output of the Lithuanian economy as a latent variable, linking deviations from the trend to inflation and unemployment through a simple Phillips curve and a simple Okun’s law relationship, respectively. That is, we use the joint behaviour of output, inflation and unemployment to derive an estimate of potential output. An additional advantage of this approach is that we can also “back out” an estimate of the natural rate of unemployment which is an important concept for policy analysis. We also extend the baseline specification to include total real credit (total credit adjusted for the general price level).

2. The baseline model

The MUC model considered in this annex includes three observable variables: (log) real GDP \(y_t\), core inflation \(\pi_t\), and the unemployment rate \(u_t\). The aim is to decompose these variables into a trend and cyclical component simultaneously based on their well-established correspondences in the literature. Let \(\bar{y}_t\) denote the unobserved trend component of (log) real GDP and \(\bar{y}_t - \gamma_1\) its cycle (or output gap); so the decomposition of \(y_t\) is written as \(y_t = \bar{y}_t + \gamma_1\). The model structure is composed of a system of three equations with three shocks as follows:

\[
\begin{align*}
\bar{y}_t &= \bar{y}_{t-1} + g_{t-1} + \varepsilon^\bar{y}_t \\
g_t &= g_{t-1} + \varepsilon^g_t \\
\gamma_1 &= \rho_1 \gamma_1 + \varepsilon^\gamma_1_t,
\end{align*}
\]

where \(\varepsilon\) are normally distributed independent white noise processes with zero means. To model the trend, we follow Harvey and Todd (1983), Harvey (1985) and Harvey et al. (2007), in which the level \(\bar{y}\) and slope \(g\), i.e. potential growth, both change slowly over time according to a random walk mechanism. These features imply a local approximation to a linear trend, often referred to as a “smooth linear trend”. Time-varying potential growth is desirable for our analysis in order to capture a wide-range of structural reforms implemented in Lithuania since the mid-1990s. Meanwhile, the output gap \(\gamma_1\) is assumed to follow an autoregressive process with coefficient \(\rho_1\). The white-noise processes represent shocks to the level of potential output \(\varepsilon^\bar{y}_t\), the growth rate of potential output \(\varepsilon^g_t\), and the output gap \(\varepsilon^\gamma_1_t\). The first two shocks cause a permanent change in output, whereas the latter only causes a temporary deviation of output from potential output, which may be understood as a temporary demand shock.

We incorporate the labour market structure to provide further identifying information for the estimation of potential output. Potential output is defined as the full employment level of output. The recognition of this definitional relationship is one of the strengths of the adopted methodology. In this structure, the unemployment rate is modelled as a sum of the trend (or the natural rate of unemployment) and cyclical component \(u_t = \bar{u}_t + \tilde{u}_t\), where the trend and cyclical component are given by

\[
\begin{align*}
\bar{u}_t &= \bar{u}_{t-1} + \varepsilon^\bar{u}_t \\
\tilde{u}_t &= \gamma_1 \bar{u}_{t-1} + \gamma_2 \gamma_1 + \varepsilon^\tilde{u}_t.
\end{align*}
\]
The natural rate of unemployment $u^*_t$ is allowed to be time-varying to capture possible changes in the labour market over time as in Laubach (2001). The unemployment gap $\hat{u}_t$ is based on Okun’s law. With this framework, we are able to derive a measure of the natural rate of unemployment which helps to assess whether the labour market is in equilibrium as well as the size of imbalances, if there are any.

A system of motion equations describing the evolution of inflation is also incorporated in the model, in line with Kuttner (1994) and Melolinna and Tóth (2016):

$$\pi_t = \pi_{t-1} + \varepsilon_t^\pi,$$

$$\hat{u}_t = \alpha_1 \pi_t - \alpha_2 \hat{u}_{t-1} + \varepsilon_t^u.$$

Trend inflation is subject to a trend shock to allow for a dynamic equilibrium in the model. The cyclical inflation component is based on a Phillips curve and linked to the evolution of the output gap with coefficients $\alpha_1$ and $\alpha_2$.

3. Accounting for credit dynamics

Recent studies concerning the UK, US and Spain (including Borio et al. (2014, 2016)) suggest that financial variables can help improve real-time estimates of the output gap. This suggestion seems natural as credit-to-GDP ratios in these countries over the 1999–2016 period are 150, 163, and 173 per cent respectively. One of the possible channels through which debt affects the real side of the economy at a high leverage ratio is the pressure on the debt service coverage ratio. The increasing cost of debt can have outsized effects on highly leveraged firms and households. When servicing debt becomes cumbersome, firms curtail investment and employment, households diminish consumption. We explore the role of financial factors for the estimation of the output gap in Lithuania by focusing on the evolution of total real credit. To do so, we follow a relatively parsimonious approach suggested by Melolinna and Tóth (2016) which embed financial information in the spirit of Borio et al. (2016, 2014) into a MUC framework. Specifically, the financial variable is assumed to affect the output gap with a lag and, therefore, the dynamics of the output gap is updated as follows:

$$\hat{y}_t = \rho_1 \hat{y}_{t-1} + \delta \hat{f}_{t-1} + \varepsilon_t^\delta,$$

where $\hat{f}_{t-1}$ represents the trend in the growth rate of real credit at time $t - 1$. Further details on the model specification and the estimation of the above equations are available in Constantinescu and Nguyen (2017).

4. Potential output and the output gap

Chart A below shows real GDP and the estimated potential output, including credit on a natural logarithmic scale. Chart B shows the associated output gap.

![Chart A. Real GDP and potential output](natural_log_scale)

![Chart B. Output gap](per_cent)
Actual output was continuously above potential output from the first quarter of 2003 to the outbreak of the financial crisis in 2008, with the output gap reaching the peak of 7 per cent in the fourth quarter of 2007. During the crisis, both actual and potential output decreased and the output gap plummeted by nearly 13 percentage points, from 5 per cent in the fourth quarter of 2008 to –8 per cent in the first quarter of 2009. The gap was closed gradually in three years, became positive in the early 2012, and has remained above zero (around 1%) ever since. To capture the uncertainty of the output gap estimate, we calculate its 90 per cent confidence intervals. As can be seen, the bounds also detect the pre-crisis expansion, with the output gap being between 3 and 10 per cent, and the post-crisis recession, with the output gap between –4 and –9 per cent. In recent periods, the lower and upper bounds of the output gap are 0 and 4 per cent respectively.

Chart C indicates the impact of the crisis on potential output. Potential growth was approximately 1.7 per cent (per quarter) in the pre-crisis period and fell temporarily to –1 per cent in the early 2009 when actual output dropped by 15 per cent. Potential growth recovered gradually and has remained around 0.6 per cent (equivalent to 2.4% per year) since 2011. Therefore, potential growth in the post-crisis period is about 1.1 percentage points per quarter (or 4.4 percentage points per year) lower than the pre-crisis level, suggesting the long-run impact of the crisis on potential output.

Chart C. Potential growth

Sources: Eurostat and Bank of Lithuania calculations.
References


