

Appendix 2

Calculating the output gap

The output gap is an important concept in the preparation of inflation forecasts and assessments of the economic outlook. However, the output gap is difficult to measure and subject to great uncertainty in practice. The techniques used by the Central Bank of Iceland and elsewhere to calculate the output gap, which have previously been described in *Monetary Bulletin* (2000/4 pp. 14-15), will be recapitulated here taking particular account of investments in the aluminium and power sectors, since these have a substantial impact on both the level of production and output potential in the economy, not only during the construction phase but also when the investments have been completed.

Definition of the output gap

The output gap is defined as the difference between actual and potential GDP as a per cent of potential GDP, i.e.:

$$(1) \quad \text{GAP}_t = \frac{Y_t - Y_t^p}{Y_t^p}$$

where GAP_t is the output gap, Y_t is GDP in real terms and Y_t^p is the potential output of the economy, all during the year t . Potential output is defined as the level of GDP that is consistent with full utilisation of all factors of production under conditions of stable inflation. Thus potential output is determined on the supply side of the economy, i.e. by capital stock, labour use and available technology.

Potential output in the long term is determined by how efficiently the available factors of production can be utilised for a given level of productivity. In the short run, however, aggregate demand can drive the level of production beyond long-term potential output. This creates macroeconomic pressures which take the form of excess demand in the goods and labour markets, eventually causing inflation to rise. If production is lower than long-term potential output, on the other hand, slack is formed which, other things being equal, lowers the rate of inflation.

Estimates of potential output are necessary in assessments of the economic situation and outlook for policy-making or other purposes. Growth resulting from an increase in potential output does not cause an increase in the rate of inflation, for example when productivity is boosted by new technology. On the other hand, if output growth is driven by an increase in demand in excess of potential output, a positive output gap may develop which will cause the rate of inflation to speed up. GDP growth in excess of long-term output potential does not always have an inflationary effect, however. If there is prior slack in the economy, businesses can meet increased demand by utilising the factors of production more efficiently. Hence estimated utilisation of the factors of production is a key assumption behind assessments of medium-term price developments.

Measuring potential output in the economy

Potential output cannot be observed directly from available data. Since it has to be estimated using statistical methods, it is subject to a high degree of uncertainty.

Various methodologies have been suggested for estimating potential output. All of them assume that GDP growth may be divided into two components: trend growth and cyclical growth. Pure statistical methods, i.e. those which are not directly derived from a theory-based approach, divide the level of production whereby:

$$(2) \quad y_t = \tau_t + c_t$$

where y is the logarithm of GDP, τ is its trend component and c is its cyclical component. The trend reflects a broad long-term growth curve around which output fluctuates. It is often regarded as a measure of potential output, although this view is not unanimously held (see e.g. Canova, 1998). Estimates of trend GDP are subject to the same complications as estimates of potential output, namely the path cannot be evaluated directly. A number of statistical approaches are possible for dividing measured time series in this way.¹ The problem is that they yield different outcomes, often with marked divergences depending on the methodology adopted.

Other methods are based on estimating the production function and using this to estimate potential output. Production is commonly described using the Cobb-Douglas specification of the production function:

$$(3) \quad Y_t = A_t N_t^\alpha K_t^{1-\alpha}$$

where Y_t is the output level of the economy at constant prices, A_t is total factor productivity (i.e. productivity of the combined factors of production (labour, capital and other factors)), N_t is labour input and K_t the capital stock, while α is the share of wages in the total value added in the economy and is assumed to be constant over time.

Central Bank of Iceland's methods for estimating potential output

For a number of years, the Central Bank has estimated the output gap in the economy. The output gap is calculated from an estimation of potential output based on the mean yielded by five different methods. One involves estimating trend GDP using the Hodrick-Prescott filter (1997) (HP).² The other four are variants of the Cobb-Douglas production function. All these methods use the current capital stock, as it changes slowly. Changes in the stock of capital are thus fully reflected in potential output. Total factor productivity is also

1. Such as polynomial trend extrapolation, Hodrick-Prescott filters, Beveridge-Nelson filters, state of space models, etc.

2. The Hodrick-Prescott filter is applied to the level of production y to estimate τ in equation (2).

found using the same method in all cases and is estimated by solving for A_t from equation (3). The HP filter is then applied to A_t to establish the trend path for total factor production. These four methodologies thus differ only in the way that they find the trend path for labour.

The simplest method is to use the HP filter to find the trend path for labour input. The other three begin by dividing labour use into its components:

$$(4) \quad N_t = H_t L_t (1 - u_t)$$

where H_t is the participation ratio, L_t is the number of individuals of working age and u_t is the unemployment rate. An attempt is then made to measure the natural rate of unemployment, i.e. the level of unemployment measured at full utilisation of the factors of production. Three of the five methods used by the Central Bank to calculate potential output are based on different estimates of the natural rate of unemployment. One applies the HP filter to the unemployment rate, whereas the other two use an assumed rate of natural employment. These set the unemployment rate at full utilisation of the factors of production in Iceland at 2.5% and 3.0%, respectively. Each of these five approaches yields a specific estimation of potential output, which is then used together with estimated output to calculate the output gap (using equation (1)).

The impact of investments in the aluminium and power sectors

Investments currently being made in aluminium smelters and power stations have a sizeable impact on GDP. It is important to distinguish between their impact on potential output and the output gap. The investment projects affect not only production but also potential output of the economy, both during the construction phase and afterwards. For this reason, special allowance needs to be made for their impact on capital stock, labour input, total factor productivity and the natural rate of unemployment when potential output is estimated using the production function (3).

To incorporate these factors, a number of the aggregates on which potential output is based need to be revalued with respect to the impact of the investments upon them. The investment cycle is assumed to be fully known. The Central Bank's macroeconomic model is then used to estimate what output, capital stock, labour input and the size of the labour force would have been, had the investments not been made. This is done by forecasting these aggregates over the construction phase without the construction projects, to produce an alternative scenario excluding the investments.

The total factor productivity trend is allowed to develop as in the alternative scenario with the addition of a productivity shock during the investment phase. This is based on calculations by the National Economic Institute that, other things being equal, GDP will increase by 1% when the smelters reach full production. This addition will be reflected in total factor productivity over several years.

The capital stock corresponding to full utilisation of the factors

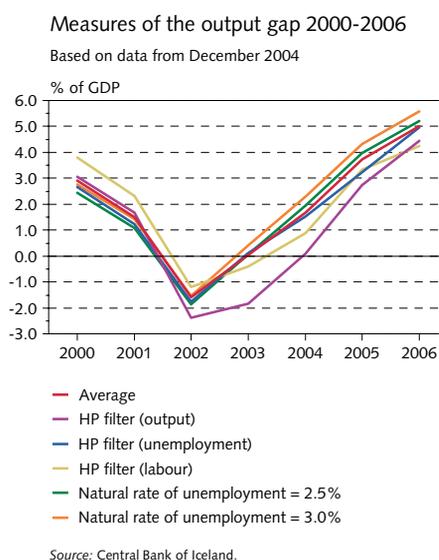
of production is allowed to develop as in the model excluding the aluminium and power sector investments. New smelters and power stations are added to the production function when they start up. At the end of the construction phase the capital stock then grows annually by the same proportion as in the scenario excluding the investments.

When using the HP filter to find the trend path for labour use, the labour input from the alternative scenario, i.e. excluding the aluminium and power sector investments, is filtered, and the imported labour for the projects is added to the filtered series. When the labour input trend is estimated using equation (4) and the natural rate of unemployment is found using an HP filter, the filter is applied to estimated unemployment excluding the investments, then the difference between the number of unemployed excluding and including the investments (calculated as a proportion of labour supply) is added to it. Labour supply is found by adding imported labour to labour supply excluding aluminium and power sector investments. This method of calculation is also used when a natural rate of unemployment of 2.5% or 3.0% is assumed.

Such an approach aims to prevent the output potential of the economy from appearing to have increased before it actually does in practice. Without this adjustment, the HP filter would increase output potential long before production begins, because it levels out fluctuations by spreading the effects of shocks in both directions. If labour supply increases, e.g. on account of imported labour for specific projects, straightforward HP filtering would cause the extra labour supply to begin exerting an impact several years before it is actually added, and even before the investment is decided.

After it became clear that the investments in the aluminium and hydropower sectors would go ahead, the simplest available method – HP filtering of the level of output itself – was discarded, because it spreads the additional future output potential back into the past as well, thereby underestimating the actual output gap. The mean of the estimated potential based on the four different versions of production function (3) is therefore used instead.

Chart 1, which uses data from December 2004, shows six estimates of the output gap. Four are based on output potential using the production function methods described above, and one shows the mean value for output potential derived from them. The output gap measured by HP filtering of GDP is also shown. The chart reveals how this method yields a smaller output gap measurement, because the HP filter spreads output potential backwards in time over many years.



Sources

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