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# Too Hot or Too Cold? Estimating the Cyclical Position of the Irish Economy

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# Too Hot or Too Cold? Estimating the Cyclical Position of the Irish Economy

Thomas Conefrey, David Staunton and Graeme Walsh[1]

## Abstract

The output gap measures the difference between the current level of output in the economy and what could be produced if all resources were employed at a sustainable level. Amongst a range of indicators, understanding the size of the output gap is useful for assessing wage and inflation developments and for considerations of the appropriate fiscal policy stance. The output gap is unobserved and must be estimated and is therefore subject to uncertainty. This *Letter* describes, implements and assesses a range of methods for estimating the output gap for Ireland. The results indicate that the output gap turned sharply positive following the economy's rapid growth in 2022 and 2023. The size of the positive output gap is estimated to have declined in 2024 but the latest estimates indicate that output is above its long-run sustainable level with a risk of overheating.

## 1. Introduction

Estimating the cyclical position of the economy – as represented by the output gap – is important for macroeconomic and fiscal surveillance. The level of the output gap can signal whether the economy is operating above or below its long-run sustainable capacity and therefore provides information as to the likely extent of inflationary pressures. If the level of activity in the economy is above that consistent with all labour and capital resources being fully utilised, this could signal a risk of excessive inflationary pressures emerging. An assessment of the cyclical position is

[1] Irish Economic Analysis Division. The views expressed in this Article are those of the authors and do not necessarily reflect those of the Central Bank of Ireland or the European System of Central Banks. We would like to thank Robert Kelly, Martin O'Brien and Gerard O'Reilly for comments on an earlier draft.

also necessary to inform the appropriate stance of budgetary policy and to assess fiscal sustainability. In particular, fiscal policy should operate in a countercyclical manner by stimulating demand when activity is persistently weak or the economy is in recession and withdrawing demand when the economy is growing rapidly above capacity. In order to ensure that fiscal policy operates in a countercyclical manner, this relies on understanding whether the economy is likely to be operating above or below capacity, an assessment which can be informed by an estimate of the output gap.

The output gap is not directly observed and must be estimated. This presents a number of challenges especially in the context of a small open economy such as Ireland. Labour supply (through migration) and capital are extremely mobile. This means that some standard approaches – such as the European Commission harmonised methodology – which are useful for some larger economies, do not perform well when applied to Irish data (Bergin and FitzGerald, 2014). Moreover, the presence of large multinational enterprises means that headline measures of economic activity such as GDP and GNP can present a misleading picture of economic developments in Ireland. Accordingly, this *Letter* focuses on estimates of the output gap using measures of activity that better reflect conditions in the domestic economy and are linked to employment growth, including GVA of the domestically-dominated sectors and GNI*.

Individual methods for estimating the output gap are sensitive to the specific data inputs and estimation techniques. Combined with the uncertainty around any estimate of this unobserved indicator, it is appropriate to consider different approaches for estimating the output gap, rather than relying on a single model or estimate.[2] In this *Letter*, we provide an overview of a range of approaches that include statistical methods, univariate and multivariate filtering methods and a production function approach. The analysis in this *Letter* builds on and updates estimates of the output gap for Ireland produced in other research including by Department of Finance, IFAC, O'Grady (2019), Clancy (2013) and the IMF.

Taking the median of the range of estimates from the methods used in this *Letter*, the resulting output gap captures well known and documented cyclical phases of growth and recession in the Irish economy, including the build up to a large positive output gap at the peak of the property and credit bubble in 2007 and the sharp reversal during the financial crisis. The estimates indicate that the post-pandemic recovery in 2022 and 2023 resulted in the emergence of a large positive output gap, signalling excess demand in the economy. The estimated output gap remains positive in 2024 but has reduced. Conditional on the current central forecasts for the economy, it is projected to fall to close to zero out to 2027 but to remain at a level where additional demand could trigger overheating pressures. We evaluate the output gap estimates by assessing their ability to explain inflation and their performance in real time. The results of both tests indicate that the approaches described in the *Letter* can form a useful part of the toolkit for assessing the cyclical position of the Irish economy.

[2] O'Grady (2019) uses a Bayesian model averaging approach to estimate output and unemployment gaps for Ireland.

The remainder of this *Letter* is structured as follows. Section 2 provides a description of the methods used to estimate the output gap. Section 3 summarises the estimates from the range of models considered and evaluates the results. Section 4 concludes.

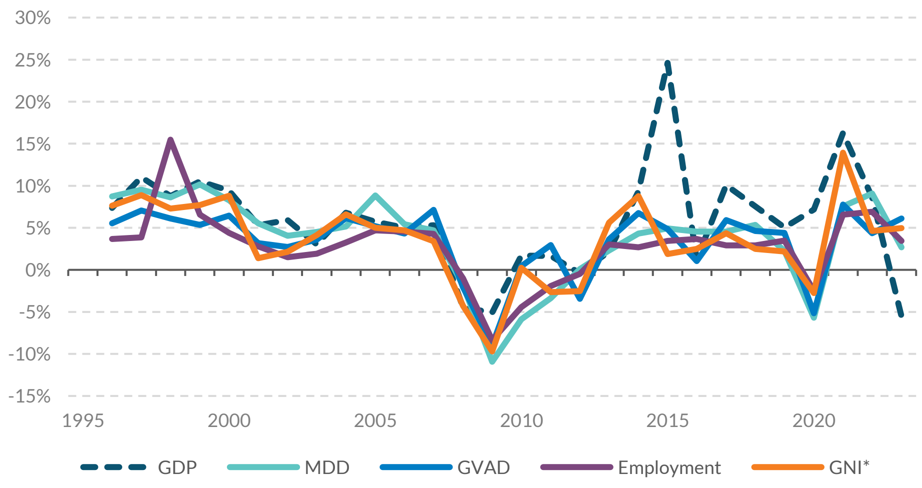
## 2. Methodology

The methods used to estimate the output gap in this *Letter* fall into two broad approaches (1) statistical filters and (2) production function method. This section provides a brief overview of the individual methods used under both approaches in this analysis.

### Statistical Filters

The goal of statistical filters is to decompose an economic time series into a trend, interpreted as representing the economy's underlying growth in potential output, and a cycle, which represents short run deviations from the trend caused by non-structural factors. The statistical methods are applied to indicators that best capture economic activity that affects the employment and incomes of Irish residents, rather than GDP. As documented by FitzGerald (2015) and Central Bank of Ireland (2021), certain global activities of large MNEs in Ireland and how these activities are measured in line with international National Accounting standards mean that there is a disconnection between GDP and measures of domestic economic activity in Ireland. For this analysis, statistical methods are estimated on official adjusted or modified measures of economic activity, in particular GNI*, MDD and Gross Value Added of the domestic sector (GVAD). The annual growth rate in each of these measures is shown in Figure 1. The trend-cycle decomposition of output is undertaken using each of the filters separately, with the results combined via a simple averaging procedure to produce the final output gap estimate.

**Figure 1: Key macroeconomic indicators (growth rates)**




Source: CSO

## HP Filter

The Hodrick-Prescott (HP) filter is widely used by economists in academia, central banking and government, in part due to its ease of use. While there is now an extensive literature presenting superior means of filtering macroeconomic data (some of which are included below), the HP filter has become a standard method for detrending time series (Hodrick and Prescott,1997). It decomposes a series into two additive components - a trend component and a residual component interpreted as the cycle. The minimisation problem is shown in equation 1.

$$\underset{\{\tau\}}{min} \sum_{t=1}^{T} (Y_t - \tau_t)^2 + \lambda \sum_{t=2}^{T-1} (\tau_{t+1} - 2_{\tau t} + \tau_{t-1})^2 \qquad (1)$$

The HP filter balances goodness-of-fit to the actual data, with a desired level of smoothness determined by a chosen parameter, λ , which controls the extent to which the filter will "smooth through" peaks and troughs in the data. It is instructive to consider what happens is very small and what happens when it is very large. If λ = 0, the second summation in equation 1 drops out and the trend will simply be equal to the original series. If, on the other hand, $\lambda \rightarrow \infty$ the procedure becomes a linear regression on a time trend.[3] The cyclical component is calculated by subtracting the trend from the original series, leaving the cycle as a residual i.e. $c_t = y_t - \tau_t$. In the business cycle literature, λ is generally set to 1600 for quarterly data and 6.25 for annual data. That is the approach taken here, following Ravn and Uhlig (2002).

## Hamilton Filter

There are a number of drawbacks with the HP filter which stem from the high level of differencing applied to the input data. This can result in detrended series that have very little relation with the underlying data generating process, and more to do with the filter itself. In the Hamilton filter, for each time period t, the value h steps ahead is compared to what would be expected based on data from $T_0 \rightarrow T_t$ (Hamilton, 2018). The gap between the two is interpreted as the cyclical component. This setup relies on the assumption that the primary reason we would be wrong about developments two years ahead is the timing of cyclical factors like an economic downturn.

There are a number of advantages to the Hamilton filter over the HP filter. The most important when analysing business cycles is that the Hamilton filter is one-sided - it does not rely on future values to generate an estimate of the cycle. This is particularly important for policymakers who require real time estimates of the business cycle, rather than historic descriptions of it. Some concerns have been raised about the Hamilton filter’s ability to reproduce business cycles (Schüler, 2021).

[3] This is demonstrated in Hamilton (2018).

### Bandpass Filter

A bandpass filter is a statistical process that removes frequencies outside of a certain range. A key advantage is that, since the bandpass filter is defined in the frequency domain rather than the time domain like other time series methods, it provides a flexible treatment of periodicity which is useful in extracting business cycles of varying lengths (Trimbur and McElroy, 2022). A bandpass filter decomposes a time series into trend and cycle by allowing only frequencies within a specified range to pass through while attenuating frequencies outside of this range. Christiano and Fitzgerald (2003) present a bandpass filter that minimises the average squared deviation between the filtered data and that which has undergone ideal band-pass filtering. They demonstrate that this bandpass filter performs well for a range of US macroeconomic aggregates such as output growth and inflation, but note that the HP filter also performs adequately for business cycle analysis.

### Kalman Filter (State-Space Model)

The Kalman filter is a recursive algorithm that predicts the underlying state of a system based on observable data available at each time period. While it was once primarily used in science and engineering disciplines it has been adapted for macroeconomic purposes. Since it uses observable data to estimate an unobservable dynamic process, it is a natural option for estimating the output gap. An important advantage of the Kalman filter is that the state space setup allows for the inclusion of additional explanatory variables that could be important in detecting the cyclical position of the economy, in contrast to the univariate filters discussed above. In this *Letter* we employ both univariate and multivariate (including unemployment and credit growth) versions of the Kalman filter. An explanation of the state space approach to estimating the output gap is presented in Annex 2.

### Production Function Method

A disadvantage of statistical filters is that they do not take into account the underlying structure of the economy. An alternative method for estimating the output gap based on economic theory is called the production function approach. The production function approach relates labour (L), capital (K), and productivity (A) to economic output (Y), and provides a richer narrative for identifying and evaluating the output gap.

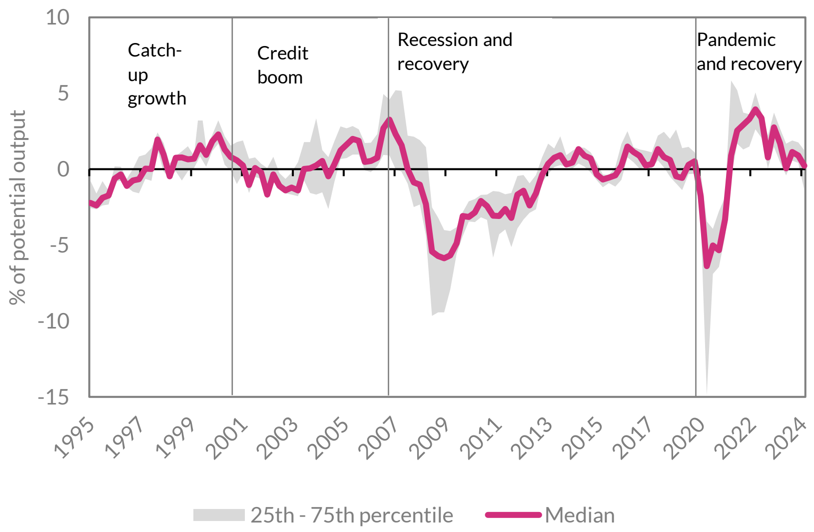
$$Y = F(A, K, L)$$

This approach originates from Solow (1957) and remains one of the most popular tools in macroeconomics. For example, the European Commission's commonly agreed method for estimating potential output for member states uses the production function approach (using GDP). The production function approach has its own disadvantages relating to functional form, parameter estimation, measurement issues, and removing the cyclical component from each of the inputs. A detailed description of the production function approach is set out in Conefrey *et al.* (2024).

## 3. Results

In order to summarise the results across all the models into a single estimate, we take a simple approach of calculating the median (Figure 2). The shaded range in the chart corresponds to the 25th and 75th percentiles of the output gap estimates and the median the 50th.

### Figure 2: Output gap estimate




Note: Median and range are calculated by taking the 25, 50th, and 75th percentile across a range of output gap estimates generated using the methods described in Section 2. Only globalisation-adjusted measures of output are included here: MDD, GNI*, and GVAD.

Four phases of Ireland's recent economic history are visible in the chart. Starting from a negative output gap in 1995, the economy's rapid export-led growth in the late 1990s and the associated fall in unemployment saw actual output catch up and then exceed its sustainable level by the early 2000s. The end of the dot com bubble in 2001 saw a slowdown in the pace of economic growth and the output gap turned marginally negative. From 2003 to 2007, the economy operated at or beyond its sustainable level as a credit-fuelled property bubble and procyclical fiscal policy stimulated demand.

In 2008, the global financial crisis and collapse of the domestic construction bubble saw output fall below its potential level as unemployment reached double digits. By 2019, the economy had completed its recovery, and overheating pressures were beginning to emerge. The Covid-19 pandemic put the economy into a deeply negative output gap in early 2020. As public health measures were lifted, the economy rebounded very strongly and the output gap turned sharply positive in 2022 and 2023. Currently as of 2024, the output gap is estimated to be lower than in 2023 but still positive, indicating that overheating risks are present. As capacity constraints bind, we expect the economy to grow more closely in line with its potential growth rate over the coming years with the output gap converging to close to zero by 2027. Starting from this position, any factors that add extra demand to the economy, such as expansionary fiscal policy, could see the output gap move into positive territory.

## Evaluation – Inflation and real-time results

A simple method of evaluating the usefulness of an output gap estimate is to assess its ability to explain inflation. In Table 1, we regress inflation on the output gap and the one-quarter lag of inflation using a simple Phillips curve specification. We compare performance across three different measures of inflation. The results indicate that the output gap has explanatory power beyond what is contained in lagged inflation, reaching statistical significance in each of the three regressions. The sign and size of the coefficients are similar to those found in a similar exercise in Casey (2019).[4] The scatterplots shown in Annex 1 demonstrate a clear positive correlation between the level of the output gap (contemporaneous and lagged) and different measures of inflation.

**Table 1: Phillips curve regressions (1996 – 2024)**

| | CPI | CPI exc. Energy and Food | CPI Services |
|---|---|---|---|
| Inflation$_{t-1}$ | 0.853***<br>(0.039) | 0.883***<br>(0.030) | 0.884***<br>(0.036) |
| Output Gap | 0.220***<br>(0.058) | 0.129***<br>(0.027) | 0.128***<br>(0.029) |
| Intercept | 0.388***<br>(0.117) | 0.226***<br>(0.071) | 0.415***<br>(0.126) |
| Observations | 117 | 113 | 109 |
| R-squared | 0.91 | 0.93 | 0.90 |

*** p<.01, ** p<.05, * p<.10

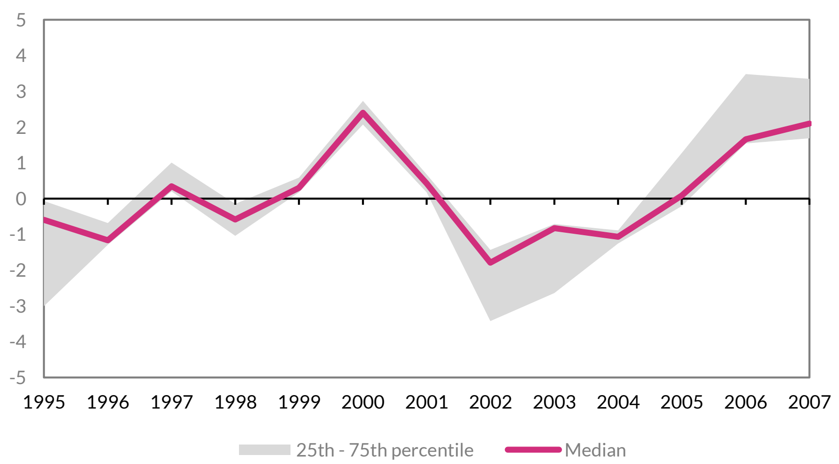
Note: In each of the three models, the lagged inflation variable uses the same inflation measure as is used in the dependant variable. Robust standard errors in brackets. *** denotes significance at 1 per cent level.

This assessment demonstrates how the output gap can help to explain variations in inflation over time. Of further relevance to policymakers is whether the estimates produced by the models when new data are released can give an accurate picture of the cyclical position of the economy in real time. To explore this issue, we look at what the model would have signalled to policymakers at key turning points in the Irish economic cycle. These turning points include the large property and credit-driven boom in the period up to 2007, the recession which followed and the Covid-19 pandemic. Unlike a historic exercise where the model benefits from data revisions and future observations, we run the model using an archive of National Accounts data that would have been available to policymakers around the time of these three turning points.

[4] While a linear relationship is specified here, there is evidence that the Phillips curve may be nonlinear (Byrne and Zekaite (2020); Benigno and Eggertsson (2022)). Future work could assess the degree of non-linearity in the relationship between the output gap and different measures of inflation.

As an example, in Figure 3 we present the output gap calculated using the first release of the 2007 National Accounts which became available in June 2008.[5] As would be expected, the median estimate detects a positive output gap in 2007. This is widely recognised as a year when the economy was overheating with low unemployment, record levels of net inward migration, rapid credit growth and a current account deficit. In addition, most of the shaded inter-quartile range lies above the median, indicating that risks of a larger positive output gap were especially pronounced. Repeating this exercise using data available for 2008 and 2021, the median output gap estimate provides plausible signals of the cyclical position of the economy at these points in time, with a negative output gap estimated for 2008 and positive output gap in 2021.

**Figure 3: Real-time output gap estimate**




Note: Median and range are calculated by taking the 25, 50th, and 75th percentile across a range of output gap estimates based on the 2007 National Accounts. Input series used are GNI, GNP and Domestic Demand. Median does not lie in centre of the inter-quartile range due to the highly asymmetric distribution of the range of estimates in some years.

## 4. Conclusion

In this *Letter*, we present an estimate of the Irish output gap based on averaging across statistical and production function approaches. The output gap provides one useful input for assessing the cyclical position of the economy and should be complemented with other analysis. Our approach focuses solely on characterising the domestic economic cycle, i.e. economic activity that is relevant for determining the employment and incomes of Irish residents. This results in an estimate that is more suited to assessing overheating pressures in the economy than approaches that use GDP.

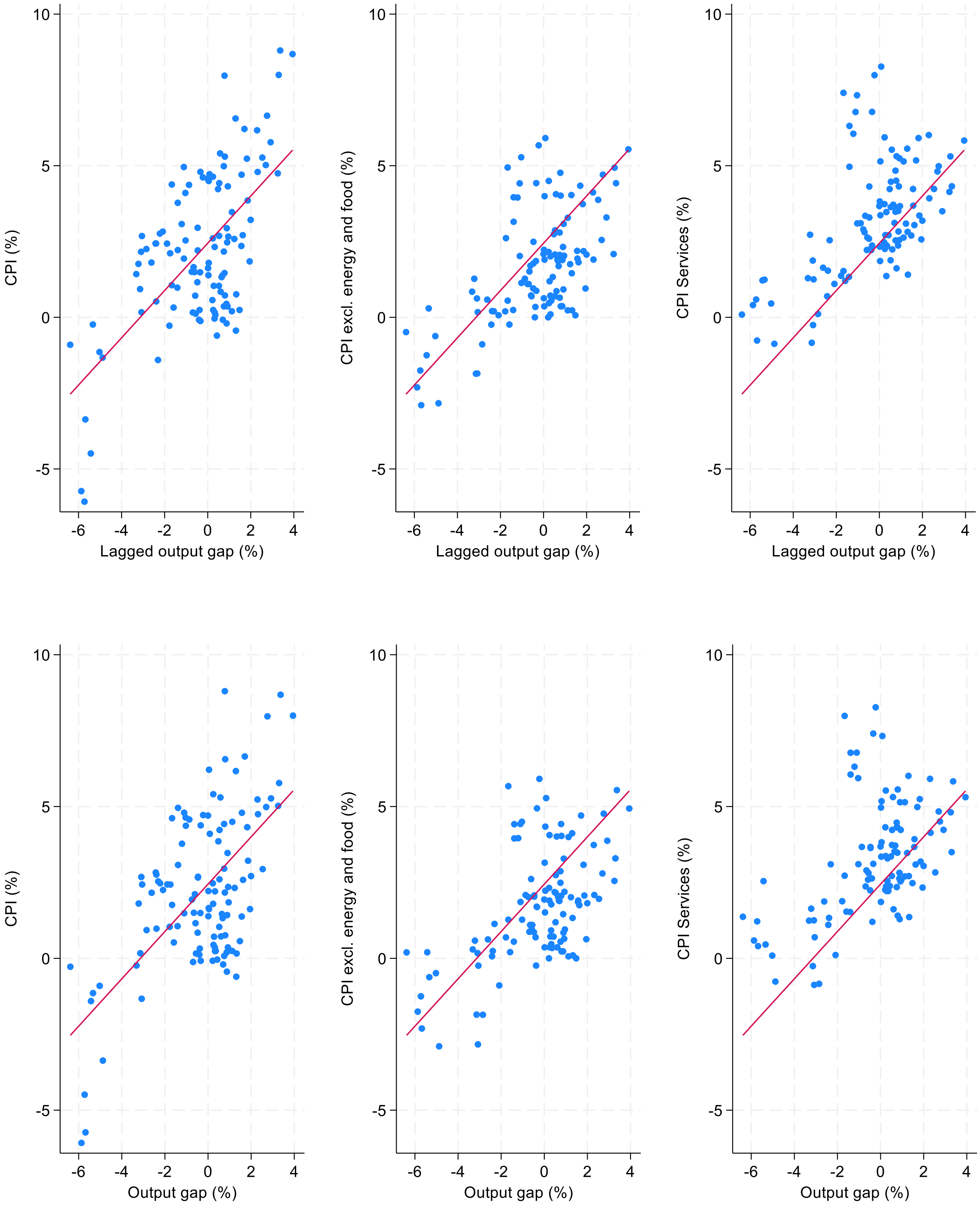
Using the estimated output gap in a simple Phillips curve shows that it helps to explain the historic variation in Irish inflation whether we focus on headline, core, or non-energy measures. Second, we use assess the real-time usefulness of the potential output model by checking what its assessment would have been for the first vintage of macroeconomic data

[5] A similar exercise is presented in Casey (2018) and Department of Finance (2018).

for key turning points in the economic cycle. We show that it would have estimated a positive output gap for 2007, with the risks (as captured by the inter-quartile range) tilted towards further increases. Based on our current projections for actual economic activity, the output gap is expected to fall to just above zero over the coming years but will remain close to a level that indicates a risk of overheating pressures emerging.

The approaches described in this *Letter* can form a useful part of the toolkit for assessing the cyclical position of the economy. At the same time, the methods are subject to estimation error since neither potential output nor the output gap are directly observable. The methods need to be reviewed over time and complemented by a wider assessment of cyclical developments, including close surveillance of incoming data.

## Annex 1: Output gap and inflation scatterplots



## Annex 2: State-Space (Kalman Filter) approach

The Kalman filter is a recursive algorithm applied to a state space model. State space models relate observable variables to unobservable variables through two equations - a state equation and a transition equation. A wide range of time series models can be applied in the state space setup, from simple autoregressive models to more advanced multivariate approaches. The basic setup is shown in equations 2 and 3.

$$Y_t^* = AY_{t-1}^* + \varepsilon_t \tag{2}$$

$$Y_t = BY_t^* + \omega_t \tag{3}$$

The state space model consists of two fundamental equations: the state equation and the observation equation. The state equation, represented by Equation 2, describes how the unobservable variable (potential output, $Y^*_t$) evolves over time. In this equation: $Y^*_t$ represents the potential output at time t; $Y^*_{t-1}$ represents the potential output at the previous time period; and A is a parameter that captures the persistence of potential output over time. The error term $\epsilon t$ captures any unexpected shocks or deviations from the predicted potential output. This equation essentially models how potential output changes over time based on its previous value, adjusted by a persistence parameter A, and perturbed by random shocks represented by $\epsilon_t$.

The observation equation, represented by Equation 3, describes how the observable variable (actual output, $Y_t$) is related to the unobservable variable (potential output, $Y^*_t$ ). In this equation, $Y_t$ represents the actual output at time t; $Y^*_t$ represents the estimated potential output at time t; and B is a parameter that captures the relationship between actual output and potential output. - $\omega_t$ is the error term, which captures any discrepancies between the actual output and the estimated potential output. This equation essentially models how actual output is related to potential output, adjusted by a scaling parameter B, and perturbed by random shocks represented by $\omega_t$. By recursively applying the Kalman filter algorithm to these equations the model can produce estimates of potential output $Y^*_t$. The output gap is then calculated in the normal way - expressing the difference between actual and potential output as a percentage of potential output.

The flexibility of state space models allows for the incorporation of additional explanatory variables. State space models can take a univariate or multivariate form, and both methods are employed here. The potential for using state-space models to measure the output gap is obvious given their focus on mapping observed data like GDP to an unobserved series (potential GDP) that we wish to estimate (Casey, 2019). In this paper we employ a univariate state space model and a multivariate state space model that includes unemployment. In line with Borio (2012) we also include a specification with private sector credit growth to capture the financial cycle.[6]

[6] White and Sheenan (2019) characterise the Irish financial cycle in a historical context.

**T**: +353 (0)1 224 6000
**E**: xxx@centralbank.ie
www.centralbank.ie

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