Output gap uncertainty – February 2016

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Abstract

Potential output (and therefore the output gap) cannot be directly observed, so estimates thereof are accompanied by uncertainty. This uncertainty consists of three components: "estimation uncertainty" - the actual estimation of the output gap; "updating uncertainty" - the output gap estimate for the current quarter may change in future when updated with new data; and "revision uncertainty" - from occasional revisions of historical GDP figures by Statistics South Africa. Updating and revision uncertainty can change the output gap estimate by as much as 1.3 percentage points within 3 years. Estimation uncertainty is due to estimating both the relationship between variables as well as the unobserved potential growth. This uncertainty can be as large as 1.7 percentage points. The size and type of uncertainty that surrounds real-time measures of the output gap should be more clearly communicated.

Introduction[1]

The output gap, measured as the difference between actual and potential output, serves as a key input in the policy decisions of the South African Reserve Bank. However, since the level of potential output (and therefore the output gap) cannot be directly observed, estimates thereof are accompanied by uncertainty. Recently the Bank released a semi-structural approach to estimating this gap.[2] This approach offers a number of desirable properties including accounting for the financial cycle and improving real-time performance, and has become the current measure of choice used by the Bank in its models. However, communication on the output gap and differing viewpoints on both its magnitude and sign have not sufficiently accounted for the fact that a significant amount of uncertainty surrounds this measure. This uncertainty can be broken down into three components: (i) ***estimation uncertainty*** – the uncertainty that arises from the actual estimation of the output gap; (ii) ***updating uncertainty*** – related to the fact that the output gap estimate for the current quarter may change in future when updated with new datapoints; and (iii) ***revision uncertainty*** – resulting from the occasional revision of historical GDP figures by Statistics South Africa (StatsSA) due to the availability of new sources of information.

The three uncertainties defined above are a useful way to address significant uncertainties around the output gap but is by no means exhaustive. An additional source of uncertainty which we abstract from in this note revolves around the identification of the "true" model defining potential growth. Trying to define this "true" model is like trying to define the meaning of life – it's an impossibility. Two points, however, are worth mentioning. First, there are a multitude of approaches to estimating the output gap from simple filters such as the HP filter to more complex structural models such as Structural VARs and Dynamic Stochastic General Equilibrium (DSGE) models that use economic theory. Each of these approaches have certain appealing properties but none is likely to be superior in all respects. Second, a single model will not be able to address all economic interactions that matter for the output gap right now, including: recent electricity constraints, the structural slowdown in China, structural unemployment, and changing economic relationships.

[1] The authors would like to thank Jessika Kramer for the compilation of the real-time GDP dataset. See Kramer, J., and Farrell, G. 2014. The reliability of South African real-time output gap estimates. ERSA Working Paper No. 428.

[2] See Anvari, V., Ehlers, N. and Steinbach, R. 2014. A semi-structural approach to estimate South Africa's potential output. SARB Working Paper 14/08.

This note aims to quantify the three components of uncertainty.[3] Also pursuant to improving how the Bank communicates the output gap, we propose adding uncertainty bands to measures of the output gap in history to emphasise the unobservable nature of this policy variable.

Model

In order to estimate the output gap we need to determine the level of potential output. Recently the Bank released a semi-structural approach to estimating the output gap.[4] This approach was introduced to address the impact of the financial cycle following the financial crisis and the realisation that this cycle matters sufficiently for how we define the real economy cycle. This is done by filtering the observable data for real GDP, while controlling for certain macroeconomic factors that may inform the estimate of the output gap- specifically credit extension and capacity utilisation. See appendix A for details on how the model is specified.

Measuring the Three Uncertainties

Estimation uncertainty

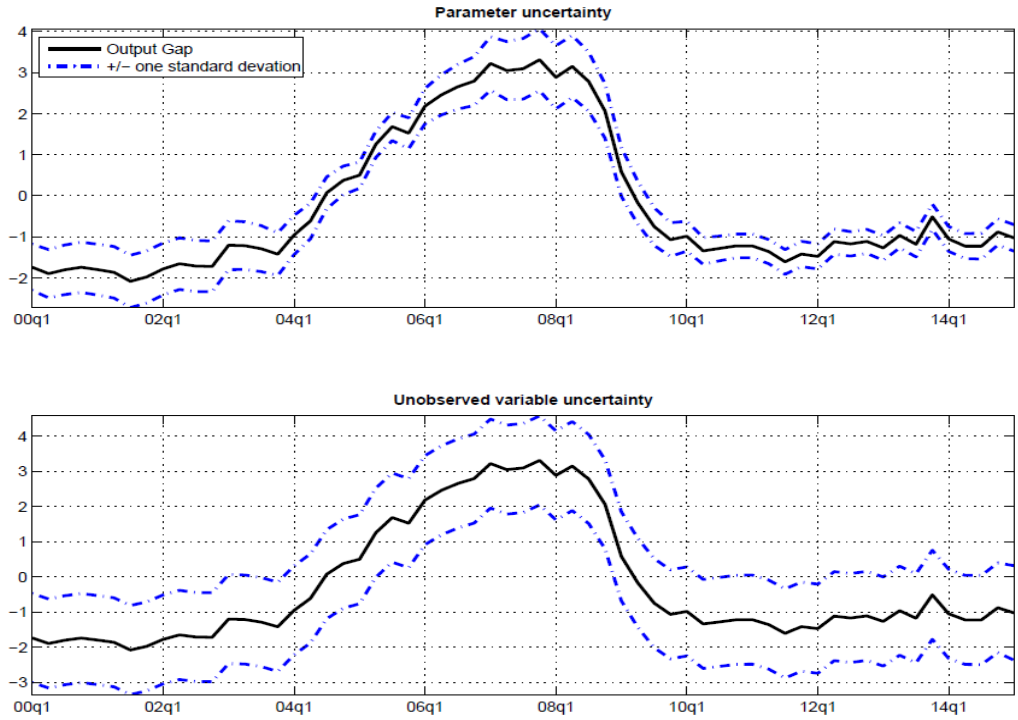
In the context of the semi-structural financial cycle adjusted model, estimation uncertainty arises from the fact that the estimated parameters (See Equations (1) and (2) in Appendix A - parameters in γ and the standard deviations of the error terms, σ_0^2 and σ_1^2) are merely sample-specific estimates of the true parameter values. In most cases this is where estimation uncertainty would end. However, since we also need to determine the value of something that is unobservable – potential output – an extra layer of uncertainty is added to the estimation process.

Figure 1 plots the uncertainty from estimating the parameters (top) and the unobservables (bottom), which make up total estimation uncertainty when combined. It is evident that the uncertainty that emanates from uncovering an unobservable variable is greater than which surrounds the parameter estimates. In fact, since 2000, the standard deviation of estimation uncertainty has been 1.7 per cent. When broken down into its subcomponents, 30 per cent of this is due to the parameters, while the rest reflects uncertainty around the estimation of the unobserved variable. This implies that the output gap estimate would on average have a standard deviation of 0.5 percentage points (i.e. 0.30×1.7) around the mean due to the parameter estimates, and 1.2 percentage points due to the unobservable variable.

[3] South Africa is also not unique in the degree of uncertainty surrounding the output gap. For example, the Norges Bank release forecasts of their output gap with the historical 2014 measure being around -0.5 per cent with 90 per cent confidence bands from -2.5 and 1 per cent. Into the forecast these bands expand to -4 and 2 per cent.

[4] See Anvari, V., Ehlers, N. and Steinbach, R. 2014. A semi-structural approach to estimate South Africa's potential output. SARB Working Paper 14/08.

Figure 1: Estimation Error



Updating and revision uncertainty

Updating uncertainty refers to the revision of the output gap measure that results from the addition of newly released data points at the end of the sample. These additional data provide supplementary information that is then used to more accurately distinguish between the part of GDP that is cyclical and that which is potential. For example, the output gap estimate for 2015Q1 changed when data for 2015Q2 became available. If one thinks of the output gap measure over a specific sample period as the outcome from a set of parameters that need to be re-estimated when new data increases the sample size, then this process is exactly the same as re-estimating a model as your time series becomes longer. The result is that a set of new parameter estimates yields a different historical evolution of potential output, and so too the output gap. In South Africa, there is evidence that updating error is the most important source of error for real-time estimates of the output gap, and that it may cause significant changes to the sign and size of the gap[5].

New data points are of course not the only source of new information. Additional information is also obtained from the periodic updating of methodology and rebasing exercises undertaken by StatsSA, as new methods and new sources of information are absorbed into determining GDP. This process introduces revision uncertainty into the output gap estimate. In other words, to what extent could the current estimate of the output gap change if the underlying data is revised? Importantly however, despite the constant likelihood of revisions at some future date, there seems to be no evidence of any bias in the direction of these revisions[6]. This also suggests that there is no systematic bias in the output gap measure.

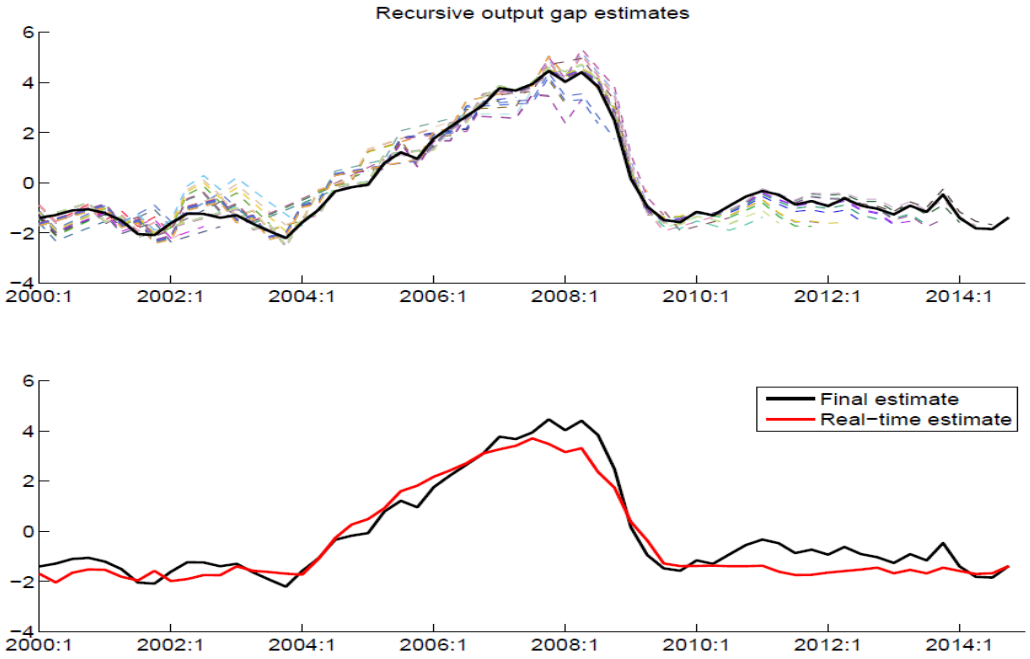
The top panel of Figure 2 shows the result of recursively estimating the output gap (dashed lines) using a vintage dataset which contains real-time GDP releases. The bold black line is the estimate of the output gap using the most recent GDP series data and constitutes the "final estimate", i.e. the estimate

[5] Kramer, J., and Farrell, G. 2014. The reliability of South African real-time output gap estimates. ERSA Working Paper No. 428. provides some evidence to the properties of real-time output gaps in SA.
[6] See van Walbeek, C. (2006). Official revisions to South African national accounts data: magnitudes and implications. South African Journal of Economics, 745-765. for more information.

containing all currently available information. The difference between the estimates at various points in time represent the update error, but also nest the revision error.

Together, update and revision error tell us how reliable real-time estimates of the output gap are – how much we can expect it to change in a quarter, a year, or ten years from now based on historical experience, as was done by Kramer and Farrell, 2014[7] (KF henceforth). First we look at the correlation of the output gap vintages (dashed lines) with the final estimate; the closer the correlation is to 100% the better are real-time estimates of the output gaps. The correlation converges to 100% as the vintage information converges to the full information set, starting at 94% for the earliest vintage (1981Q3) and averaging 98% over the entire sample. This is substantially higher than the 68% found for the best real-time estimate in the KF paper[8].

Figure 2: Real time estimates



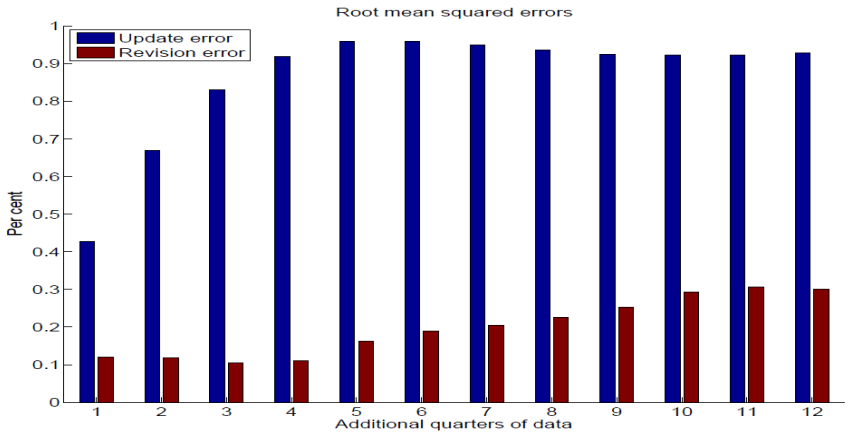
Next we look at the proportion of the time that our real-time estimate has the same sign as the final estimate (the real-time estimate consists of the last estimated point of each vintage estimate, see the bottom panel of figure 2, and is thus what we effectively thought the output gap was through history). This statistic shows that the real-time estimate has the same sign as the final estimate 88% of the time, much higher than the 65% determined in KF using various models. Based on these observations we can start to appreciate that our model performs well on a relative basis, and arguably on an absolute basis as well.

But what are the marginal contributions of updating and revision uncertainty? We answer this by calculating the root mean squared errors (RMSE) from the vintage data estimates, and then repeat the recursive estimation procedure using the full information dataset and re-calculate the RMSEs. The idea being that the "final estimate" of GDP contains all data revisions while the vintage data does not, thus the difference between the errors in the two information sets must be the revision error and the remainder must be the update error. Accordingly, Figure 3 shows that due to updating, the current output gap estimate is likely to change by roughly 0.7 percentage points after two new quarters of data become available, and by roughly 1 percentage point beyond four quarters. In contrast, the revision

[7] Kramer, J., and Farrell, G. 2014. The reliability of South African real-time output gap estimates. ERSA Working Paper No. 428.
[8] The superiority of this approach was highlighted in Anvari, V., Ehlers, N. and Steinbach, R. 2014. A semi-structural approach to estimate South Africa's potential output. SARB Working Paper 14/08.

uncertainty implies a change of about 0.3 percentage points only after 12 quarters. It is important to note that revision error may be smaller than the actual revisions to real GDP growth, since these are distributed into both potential growth and real GDP and thereby mitigates the change in the output gap. The combined change due to update and revision error is therefore 1.3 percentage points beyond 3 years.

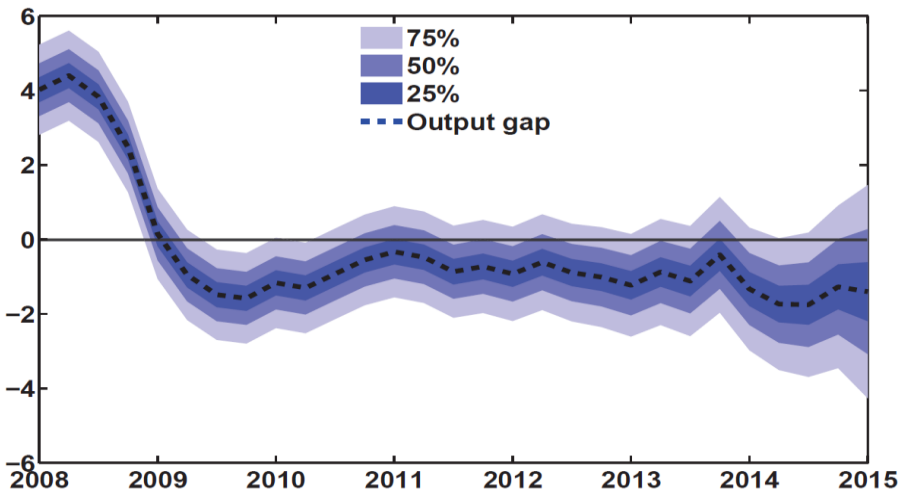
Figure 3: Error decomposition



Communicating the output gap

The challenge when communicating the output gap is that, as discussed in this note, its historical data is accompanied by significant uncertainty – a trait that does not apply to many macroeconomic variables. This note quantifies at least three of the measures of uncertainty that the Bank needs to take cognisance of when communicating potential growth and the output gap. Although uncertainty plays an important role in how policymakers and the public should think about the output gap, the addition of all these errors can get prohibitively large. This puts us between a rock and a hard place. Showing all uncertainty would be nonsensical; showing none would be imprudent. We propose that a combination of update, revision and uncertainty from estimating the unobservable be used to generate a fan chart around historical estimates of the output gap (see figure 4). From figure 3 it is evident that both update and revision uncertainty stabilise after 3 years. Hence, estimates of the output gap three years prior are unlikely to change with new data points and data revisions (see figure B.1 in Appendix B). Exploiting this narrowing into the past we can create a fan that incorporates revision and update uncertainty over the past three years as well as the uncertainty we always have around trying to estimate an unobservable.

Figure 4: Uncertainty around the output gap



Having a conceptual understanding of the uncertainty that surrounds historical estimates of the output gap is vital. First, uncertainty is substantial in real-time and this complicates the decisions of policymakers. For example, figure 4 suggests that, when accurately accounting for uncertainty, the output gap in the first half of 2015 is possibly closed (or even slightly positive) or, alternatively, it could be as large as -4 per cent. Also, depending on how the economy evolves in the future, in three years we may have a distinctly different view of the size and direction of the output gap we currently observe in 2015. Second, given this uncertainty, it is important to discount the importance placed on making decisions based on this indicator. Such decisions should therefore be substantiated with additional sources of information on the health of the economy. Third, current communication clearly indicates the proximate size of uncertainty around the output gap but does not provide evidence of the type and size of uncertainty faced by models of the output gap currently used in the decision making process. Figure 4 can change that.

Conclusion

This note highlights three sources of uncertainty that arise when estimating the output gap: estimation uncertainty, updating uncertainty, and revision uncertainty. It is found that estimation uncertainty yields an average standard deviation of 1.7 per cent around the SARBs output gap estimate. When decomposed, 1.2 percentage points thereof are owed to the uncertainty around estimating something that is unobservable, while the remaining 0.5 percentage points results from uncertainty around the parameter estimates. In addition, the most recent quarter's estimate of the output gap could change by as much as 1.0 per cent 12 quarters down the line due to the updating of GDP with new datapoints over this period. Similarly, that same quarter may change by as much as 0.3 per cent after 12 quarters, as a result of the occasional revision of historical GDP figures by StatsSA.

Appendix A: Model

Let y_t and y_t^T represent the real GDP and the unobservable level of potential output, respectively (in logs). The output gap, $y_t - y_t^T$, is the difference between these two series. The model is set up as follows:

$$\Delta y_t^T = \Delta y_{t-1}^T + \epsilon_{0,t} \quad (1)$$

Where Δy_t^T is the quarter-on-quarter change in the (unobservable) level of potential output and $\epsilon_{0,t} \sim N(0, \sigma_0^2)$ is an independent and identically distributed (IID) error term. The output gap is then determined by the following equation:

$$y_t - y_t^T = \gamma X_t + \epsilon_{1,t} \quad (2)$$

where X_t is the vector of macroeconomic factors that informs the output gap estimate. In this specific model, X_t consists of lagged values of the output gap, credit extension and capacity utilisation. As in Equation (1), $\epsilon_{1,t}$ represents an IID error that is normally distributed with a zero mean and standard deviation σ_1^2.

Appendix B: Update and revision uncertainty

Figure B.1 Update and revision uncertainty fades after three years