Commentary

Gregor W. Smith

parse: *v. tr.* resolve (a sentence) into its component parts and describe grammatically

In their thought-provoking and informative paper, Barnett, Kozicki, and Petrinec (2009) describe how the Bank of Canada used its quarterly projection model (QPM) between 1994 and 2005 to resolve changes in macroeconomic variables into their component parts. They make four distinct contributions by

(i) giving a history of the QPM,

(ii) describing how potential output was modeled with a multivariate filter that was outside the QPM and is still in use,

(iii) outlining the Bank of Canada's forecasting methods for potential output, and

(iv) illustrating the properties of multivariate forecast (or projection) errors and revisions.

In commenting on these contributions, I begin by looking at the history and forecasts of potential output as modeled by the Bank of Canada and then I draw attention to their findings concerning forecast revisions and forecast errors.

HISTORY AND FORECASTS OF POTENTIAL OUTPUT

During the 1990s the Bank of Canada began to model potential output with its extended multivariate filter (EMVF), a development that was ahead of its time. The Bank still uses this filter today. The filter is multivariate in the sense that it takes a range of indicators (e.g., the participation rate and the unemployment rate) as inputs in addition to output itself. The filter is extended in the sense that it uses economic information to define the output gap. This information includes restrictions requiring a common trend for some series or a positive correlation between the output gap and the inflation rate. Finally, the EVMF also is two sided, using both previous values of its input variables and subsequent values (or their forecasts, when potential output is being estimated for recent quarters).

The Bank's projection method thus involved two sets of parameters—one in the EVMF and another in the QPM. It is relatively easy to think of situations in which identifying parameters in the second component might depend on the parameterization in the first component. For example, the EVMF used parameter values that built in some smoothness in the series for potential output. The paper by Basu and Fernald (2009), in this issue, skeptically discusses the use of smoothness restrictions in defining potential output.

An alternative to the Bank's procedure would have been to smooth later in the process in the QPM. For example, using an unsmooth potential output series as an input in the QPM presumably would have led to a calibration of the QPM that involved smaller reactions to potential output or that used reactions to both current and lagged values of potential output, so that the smoothing

Gregor W. Smith is the Douglas D. Purvis Professor of Economics at Queen's University.

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effectively occurred at this second stage. This particular sequence of calibrations or parameterizations is now history, for the Bank of Canada has replaced the QPM with the Terms-of-Trade Economic Model (ToTEM, as described by Fenton and Murchison, 2006), but the general point about possible interdependency remains.

The EVMF is a two-sided filter, which naturally raises the questions of how to replace some future values by forecasts, how to deal with revisions in data, and what to do near the end of a time-series sample. Here my own vote favors a one-sided approach using the Kalman filter to forecast, filter, and then smooth as data vintages accumulate. Of course, the two-sided filter can be written in terms of forecasts so that it is one sided. My suggestion is simply that such a process might be a clearer place to begin, because I do not interpret Barnett, Kozicki, and Petrinec as arguing for any special interest in the parameters of the two-sided version. Anderson and Gascon (2009), also in this issue, provide a comprehensive application of a one-sided approach to U.S. data.

Historical and forecast series for potential output at the Bank of Canada are based on *different* input series and restrictions. For example, forecasts of potential output use forecasts for the capital stock and total factor productivity, while historical estimates do not use these series. These two measures obviously serve different purposes. The Bank of Canada uses potential output and the output gap to convey the idea that accumulated events or output relative to the path of potential matter to current events such as the inflation rate. That communication can counteract the view that only the most recent growth rates of macroeconomic variables matter to the subsequent evolution of the economy. I would worry, though, that having different procedures for measuring historical, potential output, and forecasting current and future potential output might hinder the communication effort.

Barnett, Kozicki, and Petrinec also discuss the issue of the sensitivity of the Bank of Canada's measure of potential output to the endpoint. As they note, noisiness in the output gap limits its usefulness as a communication device. The alternative—the Kalman-filter approach—delivers a lower weight on the observation equation in preliminary data than in revised data to reflect this uncertainty. Therefore, that alternative approach again may be a natural framework for this issue. However, it is always possible that current measures of today's potential output and output gap are simply too noisy to be useful guides to policy, as Croushore (2009) suggests in his commentary in this issue.

FORECAST REVISIONS AND FORECAST ERRORS

Barnett, Kozicki, and Petrinec next focus on the properties of multivariate forecasts, also known as projections. Readers do not observe the exact model used to produce the forecasts because that model combines the QPM with estimates of trends. But studying forecasts is a natural way to evaluate the model anyway, so their study of forecast errors and revisions between 1993 and 2005 is welcome.

A key piece of notation is that x_t^v denotes a variable *for* quarter t and measured *at* quarter v (for vintage data). For given t, as v counts up, a switch occurs from forecasts to preliminary data and then to revised data. Unobserved variables involve only a succession of forecasts. Bearing in mind this sequence, I thus apply a gestalt switch to their Figures 1 and 2. I read them from right to left so that they describe the changes over time as the date t to which the forecasts apply first is approached then left behind.

To comment on their informative reporting, I use some notation. Let us define

$$\varepsilon_t^v = x_t^v - x_t^{v-1},$$

which is the one-vintage-apart change in the forecast. With $v \leq t$ this is a forecast revision; with $v > t$ it is a forecast error. This updating applies to three different types of variables: (i) those that are eventually observed and not subsequently revised (like the consumer price index [CPI]); (ii) those that are eventually observed but then revised (like gross domestic product [GDP]); and (iii) those that are never observed (like potential GDP). To help readers understand the forecast process, Barnett, Kozicki, and Petrinec next provide three different types of statistics involving ε_t^v.

Standard Deviation Over Time

A first way to provide information about forecast errors and revisions is to document their variability over time using the standard deviation,

$$std_t\left(\varepsilon_t^v\right),$$

and then see how this varies with v. For most values of v, these standard deviations in potential GDP are roughly as large as those in revisions to actual GDP. But, of course, the revisions or errors in actual output and potential output are correlated, so the forecast revisions or errors for the output gap are much less volatile.

Correlation Across Horizons

A second way to study revisions or forecast errors is to look at their correlation over horizons:

$$corr_k\left(\varepsilon_{t+k}^v, \varepsilon_t^v\right).$$

This correlation naturally reflects the implied, underlying persistence. (Reporting correlations, if any, over time also would be interesting.)

Correlations of Forecast Errors Across Variables

A third, informative statistic is the correlation of revisions or forecast errors across macroeconomic variables. For example, using y to denote output and π to denote inflation, an interesting correlation is

$$corr_k\left(\varepsilon_{\pi k}^v, \varepsilon_{yt}^v\right).$$

This correlation is high between GDP growth and the output gap. It is low for inflation (or core inflation) and the output gap: 0.14 (or 0.05). The output gap could be measured or defined based on this correlation. I stress that that is *not* what the authors try to do. But since the Bank of Canada does use the output gap to try to communicate its views on inflation, it seems natural to test whether this "news" correlation is significantly different from zero.

Correlations of Forecast Errors Across Variables and Horizons

Perhaps the correlation at a longer horizon for inflation would be more interesting than the one between contemporaneous revisions. That would tell us how news about the output gap leads to immediate revisions in forecasts for subsequent inflation. The authors' Table 4 provides exactly this type of statistic:

$$corr\left(\varepsilon_{\pi t+k}^v, \varepsilon_{yt}^v\right).$$

Barnett, Kozicki, and Petrinec find a small, positive effect of GDP forecast errors on later inflation forecasts, an effect that is statistically significant at five to seven quarters (I am not sure of the units so cannot report on the economic significance). The policy interest rate rises too (as do market rates) but not enough to fully offset the effect of the change in the output gap on later, forecasted inflation.

Can we parameterize potential output so the output gap causes inflation? (Or can we test the causal role for a gap measured with a production function?) I think the answer is no, we cannot. At longer horizons, *nothing* should lead to revisions to inflation forecasts. Imagine a least squares regression like this:

$$\pi_{t+k}^t - 2.0 = \beta_0 + \beta_1 z_t^t.$$

In this regression, we should find that the coefficients are indistinguishable from zero for any variable z_t^t and any horizon, say, $k > 4$ quarters. Thus, this regression could not identify parameters of the output gap or potential output.

After 1995 the official inflation target (and average inflation rate) was 2 percent. Forecasts should equal that value at and beyond the horizon over which the policy interest rate has effect. Kuttner and Posen (1999), Rowe and Yetman (2002), and Otto and Voss (2009) have outlined this unforecastability of inflation departures from target under successful inflation targeting. So deviations from 2 percent in the Bank's inflation forecasts could reflect overflexible inflation targeting or an insufficient response of the policy interest rate. A role for the historical (two-sided) output gap in this regression would show that alternative measurement to be misleading. But the response of the overnight interest rate (policy) perhaps could identify learning by the central bank about the output gap.

CONCLUSION

This commentary has followed Barnett, Kozicki, and Petrinec's article by beginning with how potential is and was measured in Canada and then turning to the properties of revisions and forecast errors. But perhaps this sequence could come full circle in the Bank of Canada's research: Studying the properties of forecast (projection) errors might well lead to changes in how the Bank measures potential output.

Under inflation targeting there is no information in inflation forecasts with which to test or identify lagged effects of potential output or the output gap on inflation. So, statistically, the output gap might be better thought of not as the thing that predicts inflation but rather as the thing to which the policy interest rate reacts and, implicitly, about which the Bank of Canada learns.

I conclude with a brief observation I would like to emphasize. Full credit goes to the Bank of Canada and its researchers for publicizing these data from past projections and documenting their properties. As this article shows, these data provide a rich source of insights into the tools used in monetary policy.

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