Online Appendix for "Slaying the Beast: The Bank of Canada's Ongoing Battle With Inflation"

by Jeremy Kronick and Steve Ambler

The Taylor Rule and Its Variations

Basic Taylor Rule

The basic Taylor rule[1] says that the central bank's policy rate depends on a constant long-term neutral rate, on the difference between current inflation and the inflation target, and on the difference between the current level of GDP and its full-employment level (the output gap). It can be written as follows.

$$i_t = \bar{r} + \pi_t + \alpha(\pi_t - \pi^*) + \beta(GDP_t - GDP_t^*).$$

Here, i_t is the central bank's policy interest rate (the target overnight rate in the case of the Bank of Canada), $\bar{r}$ is the long-term real natural rate of interest,[2] π_t is the current inflation rate, π^* is the inflation target, GDP_t is the current level of real GDP,[3] GDP_t^* is the estimated level of full-capacity output, and α and β are positive constants or parameters chosen so that the central bank's choice of its policy rate is approximately optimal.

Taylor (1993) initially sets the real natural rate equal to 2.0, the inflation target to 2.0 (which also of course coincides with the Bank of Canada's target), and $\alpha = \beta = 0.5$.[4]

We use a slight variation on the original Taylor (1993) in that we allow the real neutral rate[5] to vary over time. We use real return bonds as our measure of the real neutral rate for this and for the other Fed rules.[6] We also use both output gap[7] measures from the Bank of Canada.

1 See Taylor (1993).

2 This is assumed to be constant in the simplest form of the rule.

3 In practice, this will be the best now-cast of GDP on the basis of all currently-available information.

4 This means that the policy rate reacts more than one-for-one to changes in the inflation rate. This is necessary for the real interest rate to vary in the same direction as the inflation rate and is known as the Taylor principle. If it is not satisfied, higher inflation will lead to a lower real interest rate, which will boost aggregate demand and cause inflation to increase even more, leading to instability.

5 The rate at which the economy is operating at its full potential with inflation sustainably at its target.

6 Holston et al. (2017) estimate a real neutral rate for Canada (among other countries). However, it ends in the second quarter of 2020.

7 We use the Extended Multivariate Filter and the Integrated Framework output gap measures from the Bank of Canada. See Pichette at al. (2015) for more details on each measure.

Balanced Approach

The balanced-approach rule is identical to the simple Taylor rule except that the coefficient on the output gap – 1 – is double that of the inflation coefficient. This is done to ensure the Bank responds more forcefully to the output gap than to inflation deviations from target.

Core Inflation Rule

The core inflation rule is simply the balanced approach rule where headline inflation is replaced with core inflation. For core inflation we use one of the Bank of Canada's preferred measures, CPI-Median, which from the Bank's site is "a measure of core inflation corresponding to the price change located at the 50th percentile (in terms of CPI basket weights) of the distribution of price changes in a given month."

Forward-looking Rule

The forward-looking rule is also similar to the basic Taylor rule except that instead of using contemporaneous inflation relative to target, it uses a forecast of inflation some periods ahead. The idea here is that since monetary policy works with a lag, what matters is not inflation today but inflation at some future moment in time. We use inflation forecast data from the OECD.[8] Following the Federal Reserve Bank of Cleveland, the formula is

$$i_t = r_t + \pi^f_{t+3} + 0.5\left(\pi^f_{t+3} - \pi^*\right) + 0.5(GDP_t - GDP^*_t).$$

Inertial Rule

The inertial rule takes the balanced-approach rule but acknowledges that the central bank may not want to increase rates immediately, preferring to spread out the adjustments over time. The idea behind this more gradual approach is it decreases short-term interest rate volatility. We use the inertia coefficient from the Federal Reserve Board. The formula is

$$i_t = 0.85(i_{t-1}) + 0.15\left(r_t + \pi_t + 0.5(\pi_t - \pi^*) + (GDP_t - GDP^*_t)\right).$$

Effective Lower Bound-Adjusted Rule

An economy that requires additional stimulus may run up against the constraint that the overnight rate cannot drop any further. Taylor rules as we've described so far would have trouble reconciling this fact, suggesting the central bank run significantly negative overnight rates when it cannot. The ELB-adjusted rule would tell the central bank to keep it at the ELB when the balanced approach suggests a negative rate. The ELB-adjusted rule would then prescribe a period of time where the overnight rate stays at the ELB despite the balanced-approach suggesting it was time to raise it. In formal terms:

$$i_t = maximum\{i^{BA}_t - Z_t, ELB\}$$

8 See https://data.oecd.org/price/inflation-forecast.htm for more data on the OECD inflation forecast measure. The measure is available quarterly and we interpolate to make monthly.

Table A1: Coefficients of Choudhri and Schembri Taylor Rule (Extended Output Gap)

Coefficient	Estimate	p-value
α	0.204	0.000
β	0.046	0.316
γ	0.672	0.000

Note: The smaller the p-value, the stronger the evidence in favor of the hypothesis that the coefficient is not zero, as it is in the null hypothesis.

Source: Authors' calculation.

Table A2: Coefficients of Choudhri and Schembri Taylor Rule (Integrated Output Gap)

Coefficient	Estimate	p-value
α	0.107	0.034
β	0.154	0.000
γ	0.652	0.000

Note: The smaller the p-value, the stronger the evidence in favor of the hypothesis that the coefficient is not zero, as it is in the null hypothesis.

Source: Authors' calculation.

where i_t^{BA} is the overnight rate suggested by the balanced approach rule, Z_t represents "the cumulative shortfall in monetary stimulus that occurs because short-term interest rates cannot be reduced below the ELB" (Federal Reserve Board 2022). This shortfall must then be shrunk to zero before the overnight rate comes off the ELB.

Choudhri and Schembri Taylor Rule

Choudhri and Schembri (2013) modify the simple Taylor rule (with a fixed real neutral rate) for Canada by including the US policy rate. They also use regression analysis to estimate (rather than simply choosing values thought to be approximately optimal) the values of the α and β coefficients using quarterly data from 1990:Q1 to 2001:Q4, and generate predicted values for the target overnight rate over the 2002–2007 period. We estimate with data from January 1996 until February 2020 – right before the pandemic – and then generate predicted values from March 2020 to December 2022.[9] The formula is:

$$i_t = \bar{r} + \pi_t + \alpha(\pi_t - \pi^*) + \beta(GDP_t - GDP_t^*) + \gamma_t i_t^{US}.$$

The coefficients for α, β, and γ are found in Table A1 alongside their p-values (p-values below 0.10 are significant at more than 90 percent).

9 The great financial crisis (GFC) period was included without adjustment in the estimation as the predicted values during this timeframe were not significantly below the ELB – indeed, they were never negative.