Tuning Monetary Policy Rules with Structural Macroeconomic Models

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Objectives

Monetary policy rules help central banks set their policy interest rate in response to economic shocks.

Our research objectives are:

- To calculate optimal monetary policy rules by tuning them to country and regional structural macroeconomic models.
- To develop monetary policy rules for a variety of central-bank mandates.

Introduction

When a central bank implements monetary policy by changing an interest rate the central bank is providing feedback into the economy.

This feedback is designed to reduce, and hopefully eliminate, deviations between desired and actual macroeconomic performance.

This principle of feedback – "base correcting actions on the difference between desired and actual performance" – is found extensively in natural and technological systems.

Of the forms of feedback one can use, PID control is by far the most frequently encountered and also remarkably parsimonious: corrective action is based on (1) a proportion, P, of the deviation, (2) the history of the deviation represented by the integral, I, of the deviation over time and (3) the forecast or expectation of future deviations represented by the derivative, D, of the deviation with respect to time.

In this project we use country (e.g., the United States) and region (e.g., the euro zone) structural macroeconomic models as a laboratory to tune optimal PID-based monetary-policy rules (Hawkins et al., 2015).

Monetary Policy Rules

PID-based monetary policy rules modify the well-known Taylor rule

$$r_t = r^* + \beta_0^{(\pi)}\pi_t + \beta_0^{(y)}y_t \,, \tag{1}$$

where π_t is the inflation gap and y_t is the output gap, to

$$\begin{aligned} r_t = r^* &+ \left(\beta_0^{(\pi)}\pi_t + \beta_0^{(y)}y_t\right) \\ &+ \int_0^t \left(\beta_1^{(\pi)}\pi_\tau + \beta_1^{(y)}y_\tau\right) d\tau \\ &+ \frac{d}{dt}\left(\beta_2^{(\pi)}\pi_t + \beta_2^{(y)}y_t\right) \,. \end{aligned} \tag{2}$$

This extends the Taylor rule from a consideration of the current gaps (the proportional, or P, term) to include (i) the history of policy effectiveness (the integral, or I, term) and (ii) an estimate of future policy effectiveness (the derivative, or D, term).

Structural Macroeconomic Models

To explore different macroeconomies we use the MMB: a platform that allows the user to examine the impact of different monetary-policy rules in over 120 structural macroeconomic models (Wieland et al., 2016). An example of this is the collection of impulse response functions shown in Fig. 1.

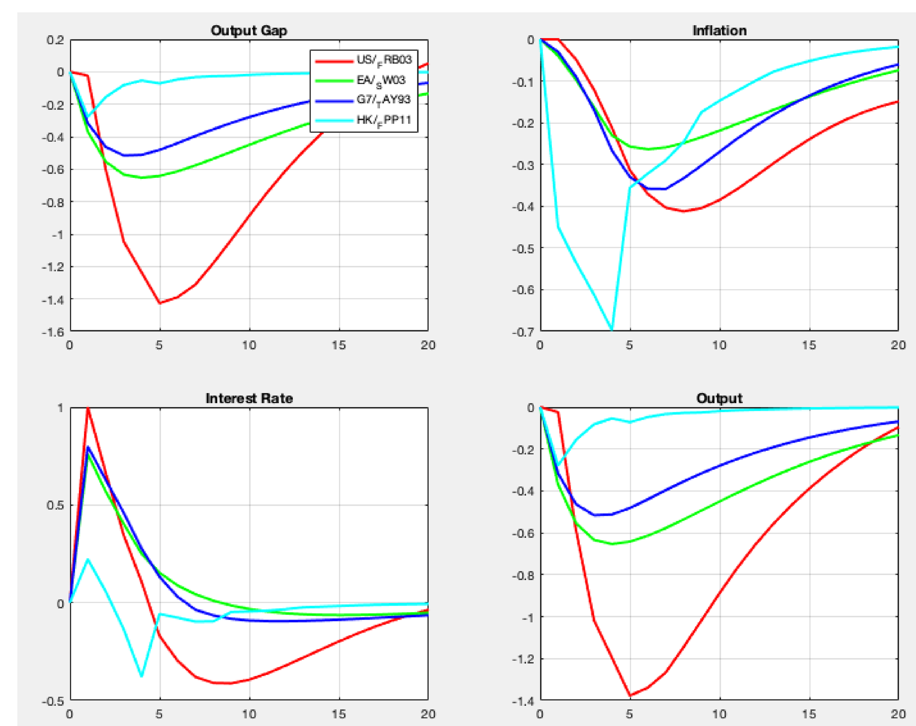

Figure 1: Impulse response functions for four macroeconomic models calculated using the MMB platform and a PID-based monetary policy rule (Hawkins et al., 2015).

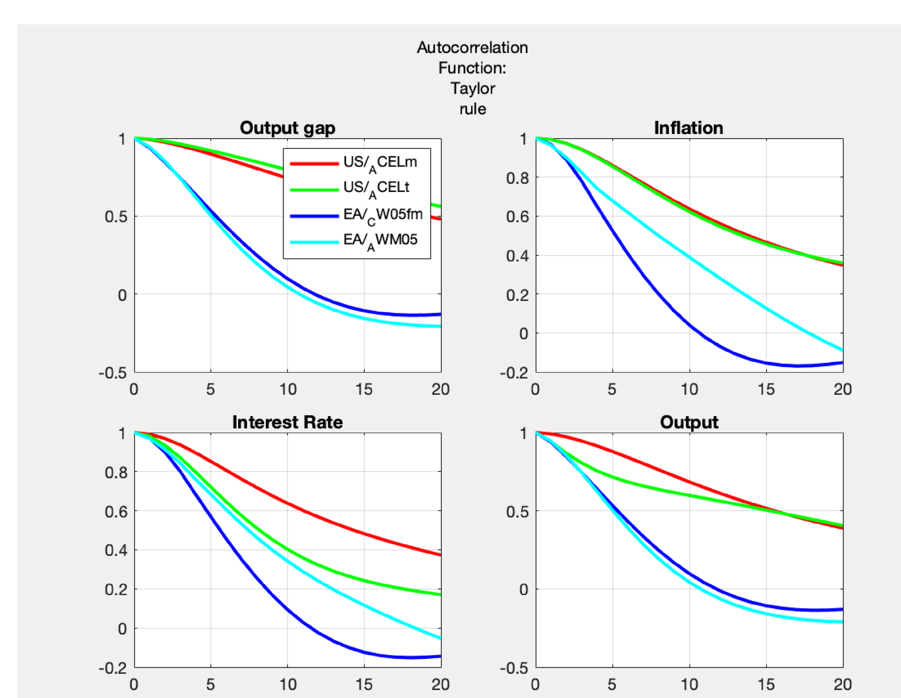

Figure 2: Autocorrelation functions.

Monetary Policy Rule Tuning

Rishab enhanced the power of the MMB platform by automating the variation of the coefficients $\{\beta_i^{(\pi)}, \beta_i^{(y)}\}$. This key accomplishment involved (i) wrapping the MatLab-based MMB in Python and (ii) the development of Python functions to run MMB from Jupyter notebooks.

With these developments the unconditional variance of the policy rate, inflation gap, and output gap are now functions of the monetary policy rule coefficients, and monetary policy rules can be tuned to desired policy outcomes such as minimizing the central bank loss function

$$L = \lambda\, \sigma_\pi^2 + (1-\lambda)\, \sigma_y^2 \tag{3}$$

where λ is the weight a given central bank places on the variance of the inflation gap.

Optimal Monetary Policy Rules

A tuning example is shown in Fig. 5 which shows a policy frontier formed by minimizing the loss function given in Eq. 3 for different values of λ while holding the policy-rate variance, σ_r^2, constant (Taylor and Williams, 2011). Each point in this graph corresponds to a unique optimized monetary policy rule.

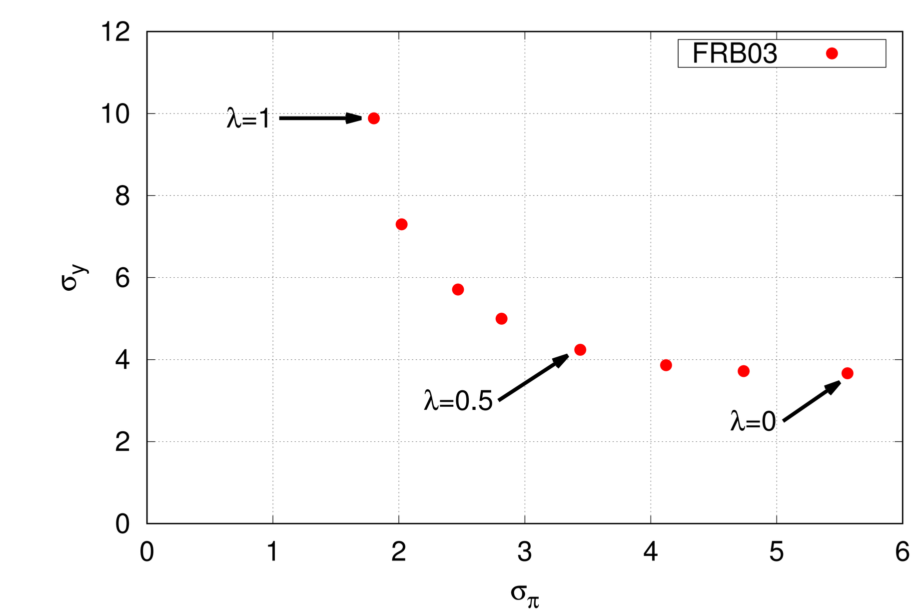

Figure 3: The policy frontier of the FRB03 model: a large-scale rational expectations two-country macroeconomic model developed by the staff of the Federal Reserve Board of Governors.

Example: U.S. Model

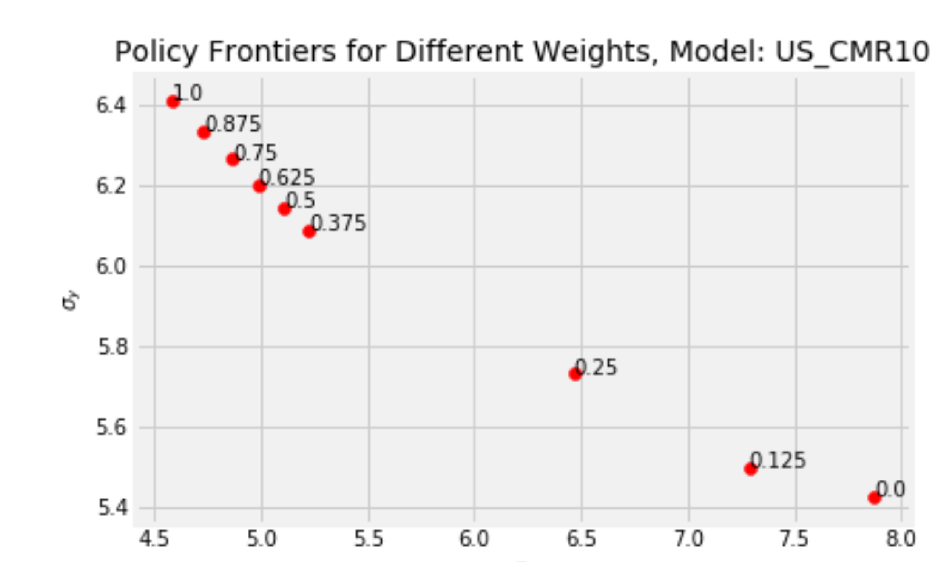

Figure 4: The Christiano et al. (2010) model.

Example: Euro Area Model

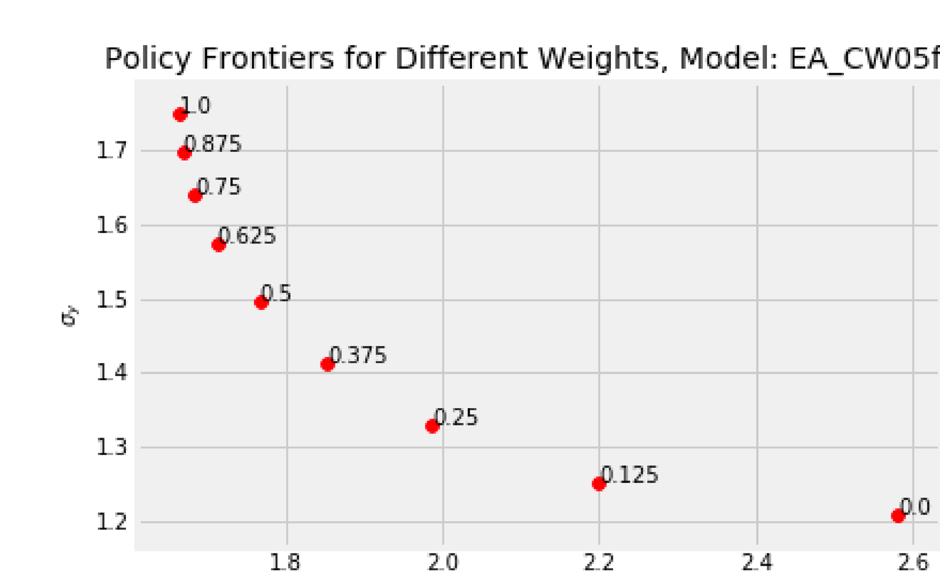

Figure 5: The Coenen and Wieland (2005) model.

Conclusion

Our work provides a menu of policy rules consistent with a wide range of central bank mandates.

We are currently developing these policy-rule menus for all country and regional models on the MMB platform

Future work includes an examination of policy-rule robustness across country and regional models

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