Optimal Simple And Implementable Monetary and Fiscal Rules

Stephanie Schmitt-Grohé
Martín Uribe

Duke University
September 2007
Welfare-Based Policy Evaluation: Related Literature
(ex: Rotemberg and Woodford, 1999)

- Two-equation Neo-Keynesian framework

- Steady state is efficient
  - Subsidies to factor inputs
  - No monetary frictions

- No fiscal policy

- No capital accumulation
This paper: Policy Evaluation in a More Realistic Environment

- Non-stochastic steady state is not efficient
  - No subsidies to undo monopolistic distortions
  - Demand for money
  - Distortionary taxation

- Fiscal policy

- Capital accumulation
Basic Theoretical Ingredients

• Monopolistic competition in product markets

• Sticky prices à la Calvo (JME, 1983) and Yun (JME, 1996)

• Money demand motivated by a cash-in-advance constraint on
  – Wage payments by firms
  – Consumption expenditures

• Capital accumulation

• Government finances a stochastic stream of public consumption by:
  – Levying either income or lump-sum taxes
  – Printing money
  – Issuing nominal non-state-contingent debt
Requirements of the Policy Rule

• **Optimality:** Policy must maximize consumers’ welfare

• **Simplicity:** Policy takes the form of rules involving a few, readily available macroeconomic variables (e.g., output, inflation, interest rates)

• **Implementability:**
  – Policy must guarantee local uniqueness of RE equilibrium
  – Policy must respect the zero lower bound on nominal rates
Main Findings

1. Optimal policy features an **active** monetary stance.  
   (However, the precise degree of responsiveness of interest rates to inflation is immaterial.)

2. Optimal monetary policy features a muted response to output.  
   (And not responding to output is critical.)

3. Optimal fiscal policy is passive.

4. The optimized simple rules attain (almost) the same welfare as the Ramsey policy.
The Model

The Household

Preferences:

\[ E_0 \sum_{t=0}^{\infty} \beta^t U(c_t, h_t) \]

Cash-in-advance constraint on consumption:

\[ m_h^t \geq v^h c_t \]

Budget constraint:

\[ E_t \left( \frac{r_{t+1} x_{t+1}}{P_t} + m_t^h + c_t + i_t + \tau_t^L \right) = \frac{x_t}{P_t} + \frac{m_{t-1}^h}{\pi_t} + (1 - \tau_t^D) [w th_t + u_t k_t] + \phi_t \]

Evolution of capital:

\[ k_{t+1} = (1 - \delta) k_t + i_t \]
Firms

• Prices are sticky as in Yun (JME, 1996).

• Wage payments are subject to a cash-in-advance constraint:
  \[ m_{it}^f \geq \nu^f w_{thit} \]

• Firm must satisfy demand at the posted price:
  \[ z_t F(k_{it}, h_{it}) - \chi \geq \left( \frac{P_{it}}{P_t} \right)^{-\eta} (c_t + g_t + i_t) \]

• Firms have monopoly power.

• Firms maximize the present discounted value of profits:
  \[ E_t \sum_{s=t}^{\infty} r_{t,s} P_s \phi_{is} \]

• Real profits:
  \[ \phi_{it} \equiv \left( \frac{P_{it}}{P_t} \right)^{1-\eta} (c_t + g_t + i_t) - u_t k_{it} - w_t h_{it} - (1 - R_t^{-1}) m_{it}^f \]
Firm’s Optimality Conditions

- Labor demand:
  
  \[ mc_{itzt}F_h(k_{it}, h_{it}) = w_t \left[ 1 + \nu f \frac{R_t - 1}{R_t} \right] \]

- Demand for capital services:
  
  \[ mc_{itzt}F_k(k_{it}, h_{it}) = u_t \]

- Optimal Pricing Decision:
  
  \[ E_t \sum_{s=t}^{\infty} r_{t,s} P_s \alpha^s \left( \frac{\tilde{P}_{it}}{P_s} \right)^{-\eta} y_s \left[ \left( \frac{\eta - 1}{\eta} \right) \frac{\tilde{P}_{it}}{P_s} - mc_{is} \right] = 0 \]
Sources of Business Cycles

- Productivity shocks, $z_t$

- Government spending shocks, $g_t$
Monetary Policy

- **Level Rule:**

\[
\ln\left(\frac{R_t}{R^*}\right) = \alpha_R \ln\left(\frac{R_{t-1}}{R^*}\right) + \alpha_{\pi} E_t \ln\left(\frac{\pi_{t-i}}{\pi^*}\right) + \alpha_y E_t \ln\left(\frac{y_{t-i}}{y}\right).
\]

- \(i = 0\), contemporaneous rule
- \(i = 1\), backward-looking rule
- \(i = -1\), forward-looking rule

- **Difference Rule:**

\[
\ln\left(\frac{R_t}{R_{t-1}}\right) = \alpha_R \ln\left(\frac{R_{t-1}}{R_{t-2}}\right) + \alpha_{\pi} \left(\frac{\pi_{t-1}}{\pi^*}\right) + \alpha_y \ln\left(\frac{y_{t-1}}{y_{t-2}}\right).
\]
Methodology For Policy Evaluation

Step 1 Compute Ramsey steady state and Ramsey dynamics

Step 2 Pick monetary and fiscal policy rule parameters $\alpha_{\pi}$, $\alpha_y$, $\alpha_R$, and $\gamma$ in $[0, 3]$ so as to maximize:

Unconditional welfare: $E\left\{\sum_{t=0}^{\infty} \beta^t U(c_t, h_t)\right\}$


Step 3 Compute (second-order accurate) welfare cost of policy rule relative to Ramsey allocation.
Welfare Cost Measure, $\lambda$

\[ E_0 \sum_{t=0}^{\infty} \beta^t U(c_t^*, h_t^*) = E_0 \sum_{t=0}^{\infty} \beta^t U(c_t^r(1 - \lambda), h_t^r) \]

* = allocation associated with interest rate feedback rule

$^r$ = Ramsey allocation
Economy I: A Cashless Sticky-Price Economy

\[ \nu^f = \nu^h = 0 \]

\[ \ln \left( \frac{R_t}{R^*} \right) = \alpha_R \ln \left( \frac{R_{t-1}}{R^*} \right) + \alpha_\pi \ln \left( \frac{\pi_t}{\pi^*} \right) + \alpha_y \ln \left( \frac{y_t}{y} \right) \]

<table>
<thead>
<tr>
<th>Policy</th>
<th>( \alpha_\pi )</th>
<th>( \alpha_y )</th>
<th>( \alpha_R )</th>
<th>Welf. Cost</th>
<th>( \sigma_\pi )</th>
<th>( \sigma_R )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ramsey Policy</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>0</td>
<td>0.01</td>
<td>0.27</td>
</tr>
<tr>
<td>Optimized Rule</td>
<td>3</td>
<td>0.0</td>
<td>0.8</td>
<td>0.000</td>
<td>0.04</td>
<td>0.29</td>
</tr>
<tr>
<td>Taylor Rule</td>
<td>1.5</td>
<td>0.5</td>
<td>–</td>
<td>0.522</td>
<td>3.19</td>
<td>3.08</td>
</tr>
<tr>
<td>Simple Taylor Rule</td>
<td>1.5</td>
<td>–</td>
<td>–</td>
<td>0.019</td>
<td>0.58</td>
<td>0.87</td>
</tr>
<tr>
<td>Inflation Targeting</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>0.000</td>
<td>0</td>
<td>0.27</td>
</tr>
</tbody>
</table>
Economy I: Implementability and Welfare

\[ \alpha_p = 0 \]

× = Implementable Rule.

○ = Welfare cost less than 0.05% of consumption.
Economy I: Importance of Not Responding to Output

\[
\begin{align*}
\text{welfare cost} \ (\lambda' \times 100)
\end{align*}
\]
The Cashless Economy
Backward- and Forward-Looking Rules

<table>
<thead>
<tr>
<th></th>
<th>$\alpha_\pi$</th>
<th>$\alpha_y$</th>
<th>$\alpha_R$</th>
<th>$%$ of $c_t$</th>
<th>$\sigma_\pi$</th>
<th>$\sigma_R$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Contemporaneous</td>
<td>3</td>
<td>0.0</td>
<td>0.8</td>
<td>0.000</td>
<td>0.04</td>
<td>0.29</td>
</tr>
<tr>
<td>Backward Looking</td>
<td>3</td>
<td>0.0</td>
<td>1.7</td>
<td>0.001</td>
<td>0.10</td>
<td>0.23</td>
</tr>
<tr>
<td>Forward Looking</td>
<td>3</td>
<td>0.1</td>
<td>1.6</td>
<td>0.003</td>
<td>0.19</td>
<td>0.27</td>
</tr>
</tbody>
</table>
Economy I: Implementability and Welfare with a Backward-Looking Rule

$\alpha_{\gamma}=0$

$\times$ = Implementable Rule.
$\circ$ = Welfare cost less than 0.05% of consumption.
Economy II:
A Monetary Sticky-Price Economy

\[ m_t^f = 0.63w_t h_t \]

\[ m_t^h = 0.35c_t \]
Long-run Policy Tradeoffs

• Price stickiness distortion calls for price stability:
  \[ \text{Inflation} = 0\% \]

• Money demand distortion calls for Friedman rule:
  \[ \text{Nominal interest rate} = 0\% \]

• Tradeoff resolved in favor of price stability
  \[ \pi^* = -0.55\% \text{ p.a.} \]
A Monetary Sticky-Price Economy

\[ \ln \left( \frac{R_t}{R^*} \right) = \alpha_R \ln \left( \frac{R_{t-1}}{R^*} \right) + \alpha_\pi \ln \left( \frac{\pi_t}{\pi^*} \right) + \alpha_y \ln \left( \frac{y_t}{y} \right) \]

<table>
<thead>
<tr>
<th>Policy</th>
<th>(\alpha_\pi)</th>
<th>(\alpha_y)</th>
<th>(\alpha_R)</th>
<th>% of (c_t)</th>
<th>(\sigma_\pi) % p.a.</th>
<th>(\sigma_R) % p.a.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ramsey Policy</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>0</td>
<td>0.01</td>
<td>0.27</td>
</tr>
<tr>
<td>Optimized Rule</td>
<td>3</td>
<td>0.0</td>
<td>0.8</td>
<td>0.000</td>
<td>0.04</td>
<td>0.29</td>
</tr>
<tr>
<td>Taylor Rule</td>
<td>1.5</td>
<td>0.5</td>
<td>–</td>
<td>0.709</td>
<td>3.93</td>
<td>3.76</td>
</tr>
<tr>
<td>Simple Taylor Rule</td>
<td>1.5</td>
<td>–</td>
<td>–</td>
<td>0.015</td>
<td>0.56</td>
<td>0.85</td>
</tr>
<tr>
<td>Inflation Targeting</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>0.000</td>
<td>0</td>
<td>0.27</td>
</tr>
</tbody>
</table>
Economy II: Implementability and Welfare

\[ \alpha \approx R(\alpha Y = 0) \]

\[ \times = \text{Implementable Rule} \quad \circ = \text{Welfare cost less than 0.05\% of consumption.} \]
Economy II: Importance of Not Responding to Output

![Graph showing the relationship between welfare cost ($\lambda^u \times 100$) and $\alpha_y$.](image)
Difference Rule

\[
\ln \left( \frac{R_t}{R_{t-1}} \right) = 0.77 \ln \left( \frac{R_{t-1}}{R_{t-2}} \right) + 0.75 \left( \frac{\pi_{t-1}}{\pi^*} \right) + 0.02 \ln \left( \frac{y_{t-1}}{y_{t-2}} \right).
\]

Welfare cost: 0.001

\[\sigma_\pi = 0.06\]

\[\sigma_R = 0.25\]
Introducing Fiscal Policy

The Government budget constraint:

\[ M_t + B_t = R_{t-1} B_{t-1} + M_{t-1} + P_t (g_t - \tau_t) \]

Let \( \ell_{t-1} \equiv (M_{t-1} + R_{t-1} B_{t-1})/P_{t-1} \)

The Fiscal Feedback Rule:

\[ \tau_t = \tau^* + \gamma (\ell_{t-1} - \ell^*) \]

\[ \ell_t = (R_t/\pi_t)(1 - \pi_t \gamma)\ell_{t-1} + R_t (\gamma \ell^* - \tau^*) + R_t g_t - m_t (R_t - 1) \]

Fiscal policy is ‘passive,’ if \( \gamma \in (0, 2/\pi^*) \)
Economy III: A Monetary Sticky-Price Model with a Fiscal Feedback Rule

\[ \tau_t = \tau_t^L \]

- Optimized Fiscal Rule: any \( \gamma \in (0, 2) \)

- Optimized Interest Rate Rule: \( \ln \left( \frac{R_t}{R^*} \right) = 3 \times \ln \left( \frac{\pi_t}{\pi^*} \right) \)

- Welfare cost = 0.001
Economy III: Implementability and Welfare

\[ (\alpha_Y = 0) \]

\( \times \) = Implementable Rule    \( \circ \) = Welfare cost less than 0.05% of consumption
Economy IV: A Monetary Sticky-Price Economy with Income Taxation

$$\tau_t = \tau_t^D y_t$$

- Long-run tradeoffs:
  - Money demand: $R = 1$
  - Sticky Prices: $\pi = 1$
  - Distortionary Income Taxation: $R > 1$ (seignorage income)
  - Cash-in-advance on labor (but not capital): $R > 1$

- Resolution of those tradeoffs

  $$\tau^D = 15.7\%$$
  $$\pi = -0.04\% \text{ p.a.}$$
Optimal Distortionary Taxation, Price Stickiness, and the Optimal Rate of Inflation
Optimal Rule-Based Stabilization Policy

\[ \alpha_\pi = 3 \quad \alpha_y = 0 \quad \gamma = 0.2 \]

welfare cost = 0.003

\[ \sigma_\pi = 0.16 \quad \sigma_R = 0.5 \quad \sigma_\tau = 0.7 \]

- Optimal monetary policy is active.

- Optimal fiscal policy is passive.

- Welfare cost relative to Ramsey virtually nil.
Economy IV: Implementability and Welfare

\[ (\alpha \gamma = 0) \]

\[ \alpha Y = 0 \]

Welfare Cost < 0.05%

Implementable Policy

\[ \times = \text{Implementable Rule} \quad \circ = \text{Welfare cost less than 0.05\% of consumption} \]
Economy IV: Importance of Not Responding to Output
Conclusions

1. Optimal monetary policy is active \((\alpha_\pi > 1)\). But the precise magnitude of \(\alpha_\pi\) plays a minor role for welfare.

2. Interest-rate feedback rules that respond to output can be significantly harmful.

3. The optimal fiscal-policy stance is passive.

4. The optimized simple monetary and fiscal rules attain virtually the same level of welfare as the Ramsey optimal policy.

5. The welfare gains associated with interest rate smoothing are negligible.

6. An interest-rate feedback rule that responds only to lagged information performs as well as one that responds to contemporaneous information.
EXTRAS
## Deep Structural Parameters

<table>
<thead>
<tr>
<th>Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\sigma$</td>
<td>2</td>
</tr>
<tr>
<td>$\theta$</td>
<td>0.3</td>
</tr>
<tr>
<td>$\beta$</td>
<td>$1.04^{-1/4}$</td>
</tr>
<tr>
<td>$\eta$</td>
<td>5</td>
</tr>
<tr>
<td>$\bar{g}$</td>
<td>0.0552</td>
</tr>
<tr>
<td>$\delta$</td>
<td>$1.1^{(1/4)} - 1$</td>
</tr>
<tr>
<td>$\nu^f$</td>
<td>0.6307</td>
</tr>
<tr>
<td>$\nu^h$</td>
<td>0.3496</td>
</tr>
<tr>
<td>$\alpha$</td>
<td>0.8</td>
</tr>
<tr>
<td>$\gamma$</td>
<td>3.6133</td>
</tr>
<tr>
<td>$\chi$</td>
<td>0.0968</td>
</tr>
<tr>
<td>$\rho_g$</td>
<td>0.87</td>
</tr>
<tr>
<td>$\sigma^{e_g}$</td>
<td>0.016</td>
</tr>
<tr>
<td>$\rho_z$</td>
<td>0.8556</td>
</tr>
<tr>
<td>$\sigma^{e_z}$</td>
<td>0.0064</td>
</tr>
</tbody>
</table>
Complete Set of Equilibrium Conditions

\[ k_{t+1} = (1 - \delta) k_t + i_t \]

\[ U_c(c_t, h_t) = \lambda_t [1 + \nu^h (1 - R_t^{-1})] \]

\[ -\frac{U_h(c_t, h_t)}{U_c(c_t, h_t)} = \frac{w_t R_t (1 - \tau_t^D)}{R_t + \nu^h (R_t - 1)} \]

\[ \lambda_t = \beta E_t \lambda_{t+1} [(1 - \tau_{t+1}^D) u_{t+1} + (1 - \delta) + \delta \tau_{t+1}^D] \]

\[ \lambda_t = \beta R_t E_t \frac{\lambda_{t+1}}{\pi_{t+1}} \]

\[ m c_t z_t F_h(k_t, h_t) = w_t \left[ 1 + \nu^f \frac{R_t - 1}{R_t} \right] \]

\[ m c_t z_t F_k(k_t, h_t) = u_t \]

\[ m_t = \nu^h c_t + \nu^f w_t h_t \]

\[ 1 = \alpha \pi_t^{-1+\eta} + (1 - \alpha) \tilde{p}_t^{-1-\eta} \]

\[ x_1^t = \tilde{p}_t^{-1-\eta} (c_t + i_t + g_t) m c_t + \alpha \beta E_t \frac{\lambda_{t+1}}{\lambda_t} \pi_t^{\eta} \left( \frac{\tilde{p}_t}{\tilde{p}_{t+1}} \right)^{-1-\eta} x_{t+1}^1, \]
\[x_t^2 = \tilde{p}_t^{-\eta}(c_t + i_t + g_t) + \alpha\beta E_t \frac{\lambda_{t+1}}{\lambda_t} \pi_{t+1}^{\eta-1} \left( \frac{\tilde{p}_t}{\tilde{p}_{t+1}} \right)^{-\eta} x_{t+1}^2 +\]

\[\frac{\eta}{\eta - 1} x_t^1 = x_t^2.\]

\[y_t = \frac{1}{s_t} [z_t F(k, h_t) - \chi]\]

\[y_t = c_t + i_t + g_t\]

\[s_t = (1 - \alpha) \tilde{p}_t^{-\eta} + \alpha \pi_t^\eta s_{t-1},\]

\[\ell_t = \frac{R_t}{\pi_t} \ell_{t-1} + R_t (g_t - \tau_t) - m_t (R_t - 1)\]

\[\tau_t = \tau_t^L + \tau_t^D y_t\]

\[(\tau_t - \tau^*) = \gamma (\ell_{t-1} - \ell^*)\]

\[\ln(R_t/R^*) = \alpha_R \ln(R_{t-1}/R^*) + \alpha_\pi E_t \ln(\pi_{t-i}/\pi^*) + \alpha_y E_t \ln(y_{t-i}/y) \quad i \in \{-1, 0, 1\}\]

either \(\tau_t^L = 0\) or \(\tau_t^D = 0\)
**The Welfare Measure:** Conditional expectation of lifetime utility

\[
\text{welfare} = V_t \equiv E_t \sum_{j=0}^{\infty} \beta^j U(c_{t+j}^r, h_{t+j}^r).
\]

**Computation:**

Write \( V_t \) as: \( V_t = g(x_t, \sigma) \)

Second-order approximation around \((x, 0)\)

\[
V_t = g(x, 0) + g_x(x, 0)(x_t - x) + g_{\sigma}(x, 0)(\sigma - 0) + \frac{1}{2}(x_t - x)'g_{xx}(x, 0)(x_t - x) + \\
g_{x\sigma}(x, 0)(x_t - x)(\sigma - 0) + \frac{1}{2}g_{\sigma\sigma}(\sigma - 0)^2 + ||o||^3
\]

Assume that at time \( t \) all state variables take their steady-state values: \( x_t = x \).
Grid Search:

- Given $i$, search over 3 policy parameters, $\alpha_{\pi}$, $\alpha_y$ and $\alpha_R$ or $\gamma$,

- Grid = [0, 3], step 0.1 $\Rightarrow$ 31 points.

$\Rightarrow$ need to approximate $V_t$ $31^3 = 29,791$ times for a given value of $i$
The Welfare Cost Measure

Let $\lambda$ denote the welfare cost of adopting policy regime $a$ instead of the reference policy regime $r$. Then $\lambda$ is defined as

$$V_{t}^{a} = E_{0} \sum_{j=0}^{\infty} \beta^{j} U((1 - \lambda)c_{t+j}^{r}, h_{t+j}^{r}).$$

For the particular functional form for the period utility function assumed

$$\lambda = \left[ 1 - \left( \frac{(1 - \sigma)V_{t}^{a} + (1 - \beta)^{-1}}{(1 - \sigma)V_{t}^{r} + (1 - \beta)^{-1}} \right)^{1/(1-\sigma)} \right]$$

Up to second-order accuracy:

$$\lambda \approx \frac{V_{t}^{r}(x,0) - V_{t}^{a}(x,0)}{(1 - \sigma)V_{t}^{r}(x,0) + (1 - \beta)^{-1}} \times \frac{\sigma_{\epsilon}^{2}}{2}$$