Optimal Simple And Implementable Monetary and Fiscal Rules

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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 <u>active</u> 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:

$$m_t^h \geq v^h c_t$$

Budget constraint:

$$E_t \frac{r_{t,t+1} x_{t+1}}{P_t} + m_t^h + c_t + i_t + \tau_t^L = \frac{x_t}{P_t} + \frac{m_{t-1}^h}{\pi_t} + (1 - \tau_t^D)[w_t h_t + u_t k_t] + \tilde{\phi}_t$$

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:

$$m_{it}^f \geq \nu^f w_t h_{it}$$

- 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:

$$\text{mc}_{it} z_t F_h(k_{it}, h_{it}) = w_t \left[1 + \nu^f \frac{R_t - 1}{R_t} \right]$$

- Demand for capital services:

$$\text{mc}_{it} z_t F_k(k_{it}, h_{it}) = u_t$$

- Optimal Pricing Decision:

$$E_t \sum_{s=t}^{\infty} r_{t,s} P_s \alpha^s \left(\frac{\tilde{P}_{it}}{P_s} \right)^{-\eta} y_s \left[\left(\frac{\eta - 1}{\eta} \right) \frac{\tilde{P}_{it}}{P_s} - \text{mc}_{is} \right] = 0$$

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 α_π, α_y, α_R, and γ in $[0, 3]$ so as to maximize:

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

(using second-order approximation package of Schmitt-Grohé and Uribe, 2004)

Step 3 Compute (second-order accurate) welfare cost of policy rule relative to Ramsey allocation.

Welfare Cost Measure, λ

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

* = allocation associated with interest rate feedback rule
^{r} = Ramsey allocation

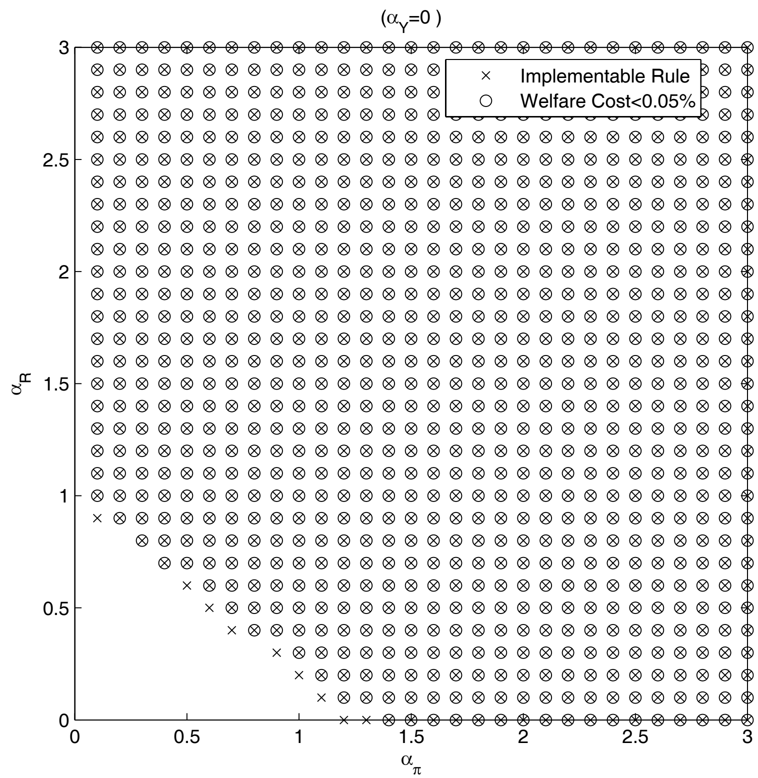
Economy I: A Cashless Sticky-Price Economy

$$\nu^f = \nu^h = 0$$

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

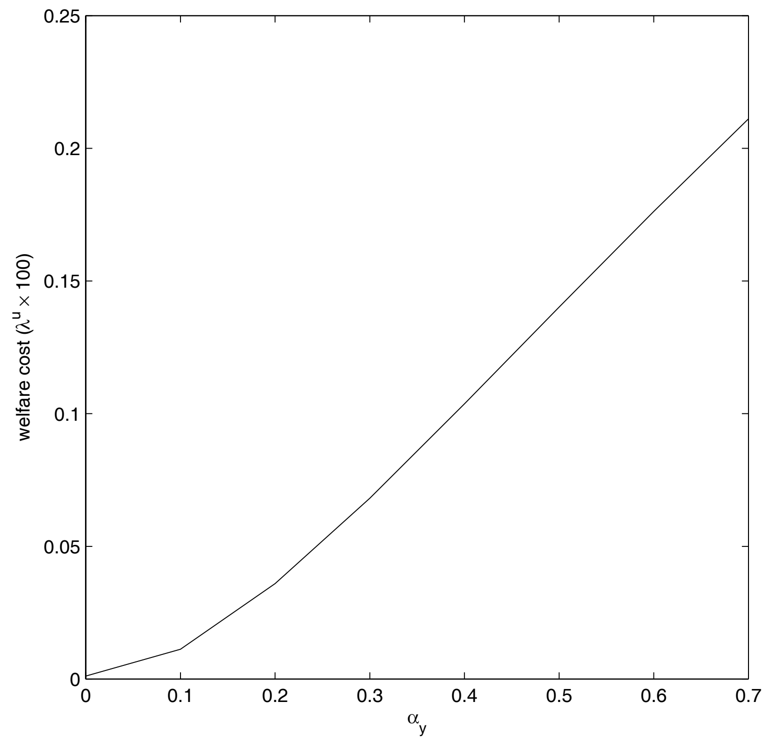
	α_π	α_y	α_R	Welf. Cost % of c_t	σ_π % p.a.	σ_R % p.a.
Ramsey Policy	–	–	–	0	0.01	0.27
Optimized Rule	3	0.0	0.8	0.000	0.04	0.29
Taylor Rule	1.5	0.5	–	0.522	3.19	3.08
Simple Taylor Rule	1.5	–	–	0.019	0.58	0.87
Inflation Targeting	–	–	–	0.000	0	0.27

Economy I: Implementability and Welfare



$\times$ = Implementable Rule. $\circ$ = Welfare cost less than 0.05% of consumption.

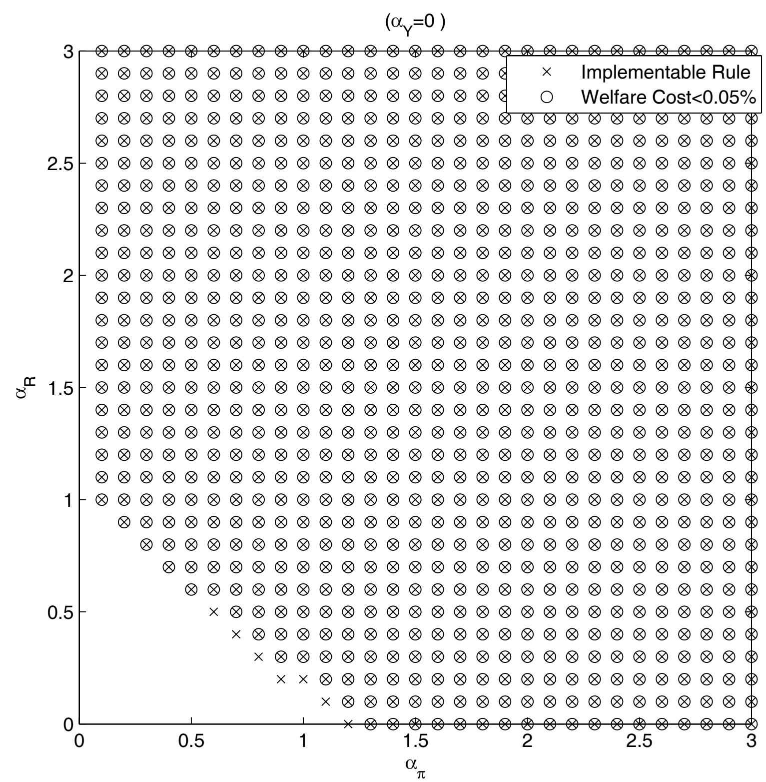
Economy I: Importance of Not Responding to Output



The Cashless Economy
Backward- and Forward-Looking Rules

	α_π	α_y	α_R	Welfare Cost % of c_t	σ_π	σ_R
Contemporaneous	3	0.0	0.8	0.000	0.04	0.29
Backward Looking	3	0.0	1.7	0.001	0.10	0.23
Forward Looking	3	0.1	1.6	0.003	0.19	0.27

Economy I: Implementability and Welfare with a Backward-Looking Rule



$\times$ = Implementable Rule. $\circ$ = Welfare cost less than 0.05% of consumption.

Economy II:
A Monetary Sticky-Price Economy

$$m_t^f = 0.63 w_t h_t$$

$$m_t^h = 0.35 c_t$$

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

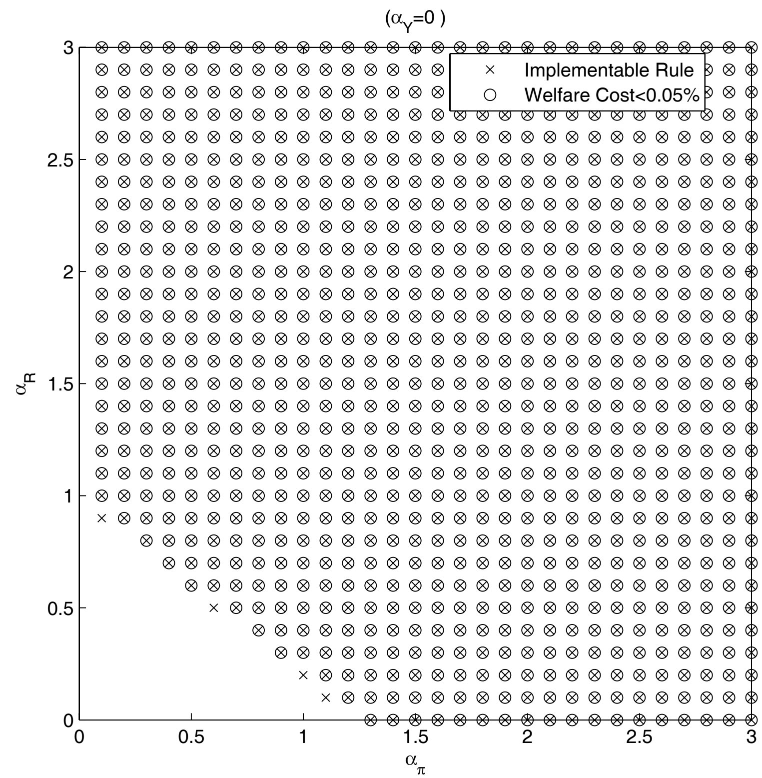
$$\pi^* = -0.55\ \%\ \text{p.a.}$$

A Monetary Sticky-Price Economy

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

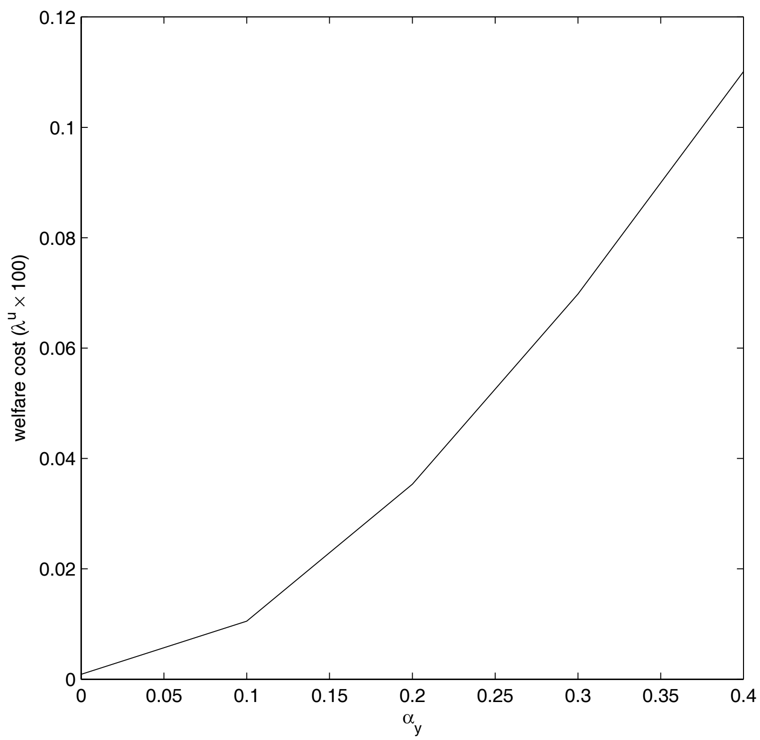
	α_π	α_y	α_R	Welfare Cost % of c_t	σ_π % p.a.	σ_R % p.a.
Ramsey Policy	–	–	–	0	0.01	0.27
Optimized Rule	3	0.0	0.8	0.000	0.04	0.29
Taylor Rule	1.5	0.5	–	0.709	3.93	3.76
Simple Taylor Rule	1.5	–	–	0.015	0.56	0.85
Inflation Targeting	–	–	–	0.000	0	0.27

Economy II: Implementability and Welfare



$\times$ = Implementable Rule $\circ$ = Welfare cost less than 0.05% of consumption.

Economy II: Importance of Not Responding to Output



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

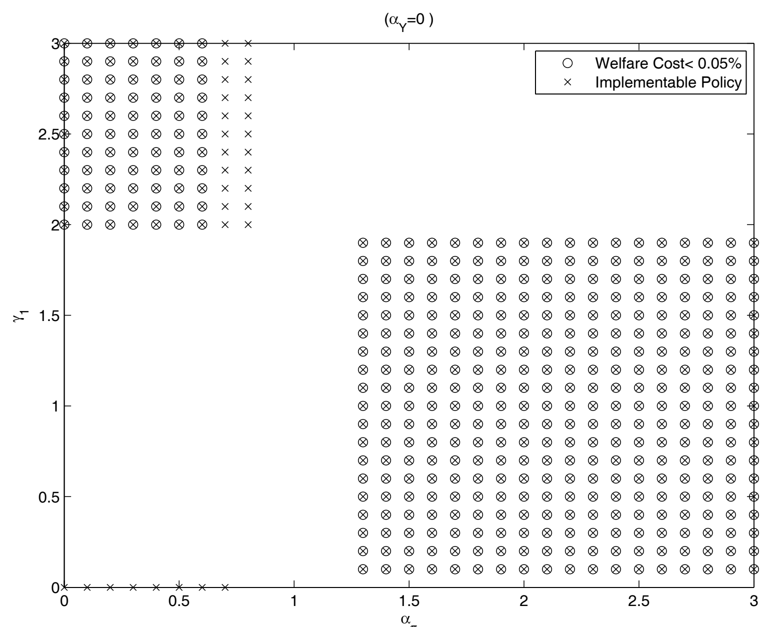
$$\tau_t = \tau_t^L$$

- 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



$\times$ = Implementable Rule $\circ$ = Welfare cost less than 0.05% of consumption

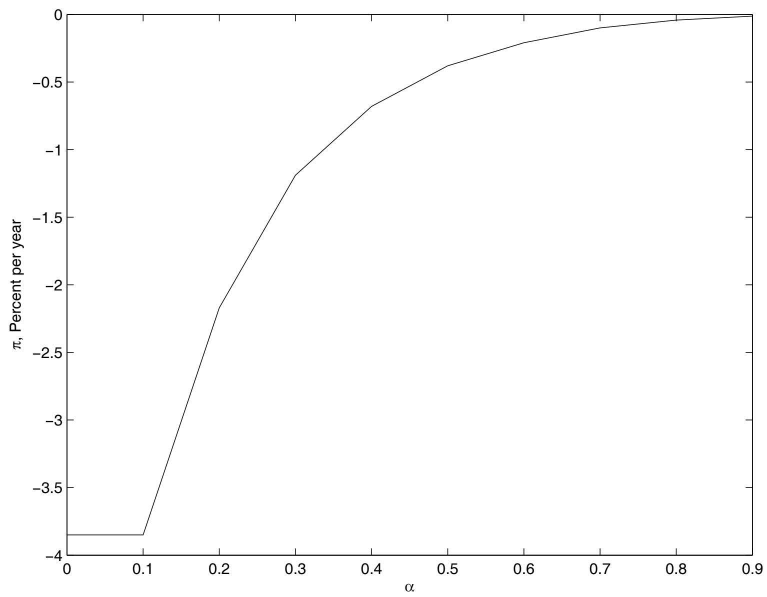
Economy IV: A Monetary Sticky-Price Economy with Income Taxation

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

- 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

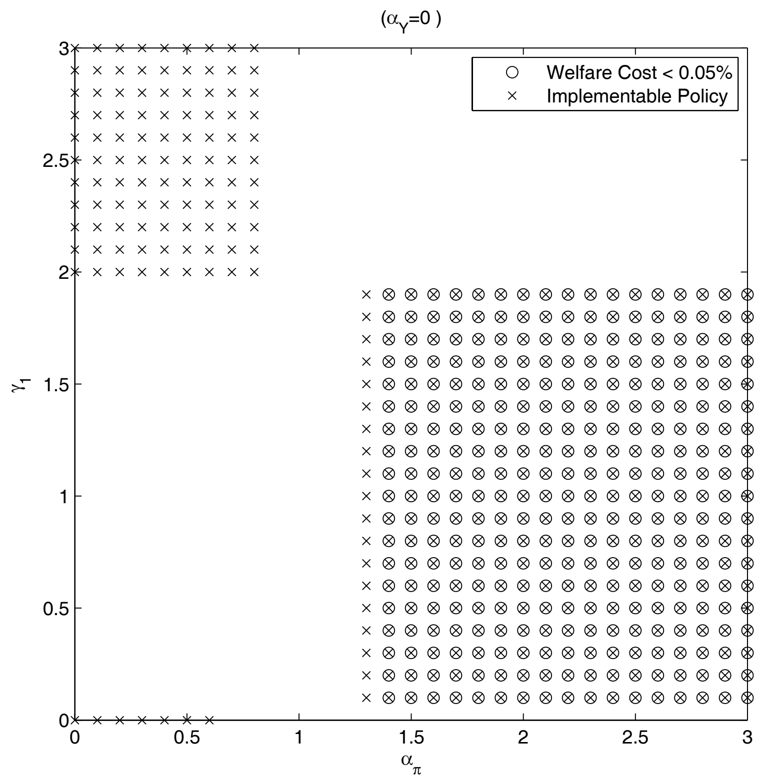
$$\alpha_\pi = 3 \quad \alpha_y = 0 \quad \gamma = 0.2$$

$$\text{welfare cost} = 0.003$$

$$\sigma_\pi = 0.16 \quad \sigma_R = 0.5 \quad \sigma_\tau = 0.7$$

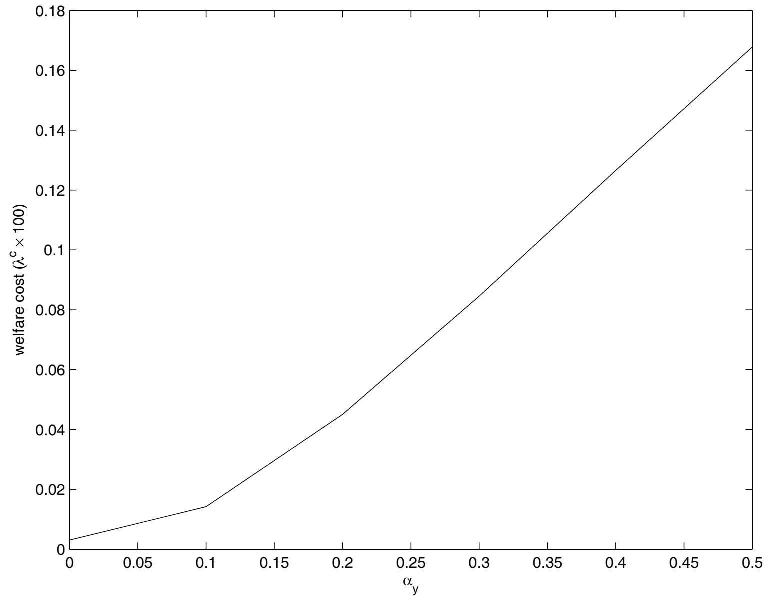
- Optimal monetary policy is active.
- Optimal fiscal policy is passive.
- Welfare cost relative to Ramsey virtually nil.

Economy IV: Implementability and Welfare



$\times$ = Implementable Rule $\circ$ = 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 α_π 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

	Value	Description
σ	2	Preference parameter, $U(c,h) = \{[c(1-h)^{\gamma}]^{1-\sigma} - 1\}/(1-\sigma)$
θ	0.3	Cost Share of capital, $F(k,h) = k^{\theta}h^{1-\theta}$
β	$1.04^{-1/4}$	Quarterly subjective discount rate
η	5	Price elasticity of demand
$\bar{g}$	0.0552	Steady-state level of government purchases
δ	$1.1^{(1/4)} - 1$	Quarterly depreciation rate
ν^f	0.6307	Fraction of wage payments held in money
ν^h	0.3496	Fraction of consumption held in money
α	0.8	Share of firms that cannot change their price each period
γ	3.6133	Preference Parameter
χ	0.0968	Fixed cost parameter
ρ_g	0.87	Serial correlation of government spending
σ^{ϵ^g}	0.016	Standard Deviation of innovation to government purchases
ρ_z	0.8556	Serial correlation of productivity shock
σ^{ϵ^z}	0.0064	Standard Deviation of innovation to productivity shock

Complete Set of Equilibrium Conditions

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

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

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

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

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

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

$$\text{mc}_t z_t F_k(k_t, h_t) = u_t$$

$$m_t = \nu^h c_t + \nu^f w_t h_t$$

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

$$x_t^1 = \tilde{p}_t^{-1-\eta}(c_t + i_t + g_t)\text{mc}_t + \alpha\beta E_t \frac{\lambda_{t+1}}{\lambda_t}\pi_{t+1}^{\eta}\left(\frac{\tilde{p}_t}{\tilde{p}_{t+1}}\right)^{-1-\eta} x_{t+1}^1,$$

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

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

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

$$y_t = c_t + i_t + g_t$$

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

$$\ell_t = (R_t/\pi_t)\ell_{t-1} + R_t(g_t - \tau_t) - m_t(R_t - 1)$$

$$\tau_t = \tau_t^L + \tau_t^D y_t$$

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

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

either $\tau_t^L = 0$ or $\tau_t^D = 0$

The Welfare Measure: Conditional expectation of lifetime utility

$$\text{welfare } = V_t \equiv E_t \sum_{j=0}^{\infty} \beta^j U(c^r_{t+j}, h^r_{t+j}).$$

Computation:

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

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

$$\begin{aligned} V_t &= g(x,0) + g_x(x,0)(x_t - x) + g_\sigma(x,0)(\sigma - 0) \\ &+\frac{1}{2}(x_t - x)' g_{xx}(x,0)(x_t - x) + \\ &g_{x\sigma}(x,0)(x_t - x)(\sigma - 0) + \frac{1}{2} g_{\sigma\sigma}(\sigma - 0)^2 + ||o||^3 \end{aligned}$$

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, α_π, α_y and α_R or γ,

- 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 λ denote the welfare cost of adopting policy regime a instead of the reference policy regime r. Then λ 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:

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