Monetary Policy, Doubts and Asset Prices

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Introduction

- Central issue in macroeconomics is agent's expectations formation.
- Economic agents might face model uncertainty.
- Model uncertainty and ambiguity aversion help explaining asset prices.
- This paper focuses on the following question:

  What is optimal monetary policy when the private sector doubts the model and is ambiguity averse?

Motivation

- Private sector model uncertainty may give rise to new distortions in decentralized allocations.
- Private sector model uncertainty may change policy transmission.

Literature

- Optimal monetary policy in the standard New Keynesian model

  Woodford (2003)

- Doubts, robust decision making and asset prices

  Hansen and Sargent (2005), Barillas, Hansen and Sargent (2009)...

- Doubts, robust decision making and business cycles

  Ilut and Schneider (2011)

- Monetary policy in models with fear of misspecification

  Dennis (2010), Woodford (2010), Adam and Woodford (2011)

Modeling distorted beliefs: Hansen-Sargent

- $\pi(s^t)$: **reference** probability measure on histories s^t
- $\tilde{\pi}(s^t)$: **subjective** probability measure on histories s^t
- $G(s^t)$: Radon-Nykodym type of derivative, $\tilde{E}[X_t] = E[G_t X_t]$.
- Multiplier preferences:

$$\min_{\{g_{t+1}\}} E_{t_0} \left\{ \sum_{t=t_0}^{\infty} \beta^{t-t_0} G_t U(C_t, L_t) + \kappa\beta \sum_{t=t_0}^{\infty} \beta^{t-t_0} E_t[G_{t+1} \ln g_{t+1}] \right\},$$

$$\begin{aligned} G_{t_0} &= 1, \\ G_{t+1} &= g_{t+1} G_t, \\ E_t g_{t+1} &= 1, \\ \kappa &> 0, \\ \beta &< 1. \end{aligned}$$

Household's technology and budget constraints

- We assume

$$U(C_t, L_t) = \log\left(C_t\,(1 - L_t)^{\eta}\right).$$

- Technologies and budget constraints:

$$C_t = \left[\int_0^1 c_t(j)^{\frac{\theta}{\theta-1}}\,dj\right]^{\frac{\theta-1}{\theta}},$$

$$K_{t+1} = \left(1 - \delta - \phi\left(\frac{I_t}{K_t}\right)\right)K_t + I_t,$$

$$P_t(C_t + I_t) + x_t Q_t = x_{t-1}\left(Q_t + D_t\right) + W_t N_t + P_t^k K_t,$$

Household's FOCs

- Non-expected utility representation (alike Epstein - Zin):

$$
\begin{aligned}
V_t &= (C_t L_t^{\eta})^{1-\beta}[\mathbf{E}_t(V_{t+1}^{1-\psi})]^{\frac{\beta}{1-\psi}} \\
\text{where:} \quad \psi &\equiv 1 + \frac{1}{\kappa(1-\beta)} > 1 \\
g_{t+1} &= \frac{V_{t+1}^{1-\psi}}{E_t V_{t+1}^{1-\psi}},
\end{aligned}
$$

- First order conditions for C, L , and K
  - Optimal consumption basket

$$
c_t(j) = C_t \left(P_t^j / P_t \right)^{-\theta}
$$

  - Optimal labor supply

$$
\frac{U_l(C_t, L_t)}{U_c(C_t, L_t)} = \frac{W_t}{P_t}
$$

Household's FOCs

- Optimality condition with respect to capital

$$1 = \tilde{\mathbf{E}}_t(m_{t,t+1} r^K_{t+1}) = \underbrace{E_t(m_{t,t+1} r^K_{t+1})}_{\textbf{Standard Term}} + \underbrace{cov_t(g_{t+1}; m_{t,t+1} r^K_{t+1})}_{\textbf{Distortion due to Doubts}},$$

$$\text{where:} \quad r^K_{t+1} \equiv \frac{1}{q_t}\frac{P^k_{t+1}}{P_{t+1}} + \left[1 - \delta - \phi\left(\frac{I_{t+1}}{K_{t+1}}\right) + \phi'\left(\frac{I_{t+1}}{K_{t+1}}\right)\frac{I_{t+1}}{K_{t+1}}\right]\frac{q_{t+1}}{q_t}$$

$$m_{t,t+1} \equiv \beta\frac{U_c(C_{t+T}, L_{t+T})}{U_c(C_t, L_t)}, \quad q_t \equiv \frac{1}{1 - \phi'\left(\frac{I_t}{K_t}\right)}.$$

Firms

- Mass 1 of monopolistic producers
- Firm j's production technology:

$$Y_t(j) = (K_t^j)^{\alpha}(A_t N_t^j)^{1-\alpha},$$

- Nominal value of a generic firm j:

$$Q_t^j + D_t^j = \tilde{\mathbf{E}}_t \left\{ \sum_{T=t}^{\infty} M_{t,T}[P_T^j Y_T(j) - W_T N_T^j - P_T^k K_T^j] \right\},$$

$$= E_t \left\{ \sum_{T=t}^{\infty} \frac{\mathbf{G}_{t+T}}{\mathbf{G}_t} M_{t,T}[P_T^j Y_T(j) - W_T N_T^j - P_T^k K_T^j] \right\}$$

where $M_{t,t+T} \equiv \beta \frac{U_c(C_{t+T}, L_{t+T})}{U_c(C_t, L_t)} \frac{P_t}{P_{t+T}}$

Firm's FOCs

- If Calvo lottery allows: choose $\{P^j_T, L^j_T, K^j_T\}$ to maximize $Q^j_t + D^j_t$.
- Otherwise: $P^j_T = P^j_{T-1}$, and choose $\{L^j_T, K^j_T\}$ to maximize $Q^j_t + D^j_t$.
- First order conditions wrt $\{L^j_T, K^j_T\}$:
  - Optimal labor and capital demand satisfy the following equations

$$\frac{K^j_t}{N^j_t} = \frac{\alpha}{1-\alpha}\frac{W_t}{P^k_t}$$

$$N^j_t = \left(\frac{K^j_t}{N^j_t}\right)^{-\alpha} \frac{Y_t}{A^{1-\alpha}_t}\left(\frac{P^j_t}{P_t}\right)^{-\theta}$$

where: $\quad Y_t = C_t + I_t.$

Firms' price setting

- Optimal price setting condtion:

$$\frac{p_t^*}{P_t} = \left[\mu \frac{\tilde{\mathbf{E}}_t \left\{ \sum_{T=t}^{\infty} (\beta\gamma)^{T-t} U_c(C_T, L_T) Y_T mc_T \right\}}{\tilde{\mathbf{E}}_t \left\{ \sum_{T=t}^{\infty} (\beta\gamma)^{T-t} U_c(C_T, L_T) Y_T \right\}} \right]^{\theta - 1},$$

where $\mu = \theta/(\theta - 1)$.

- For intuition, consider the case $\alpha = 0$, i.e. no capital:

$$\frac{p_t^*}{P_t} = \left[\underbrace{\mu \frac{\sum_{T=t}^{\infty} (\beta\gamma)^{T-t} E_t\left(mc_T\right)}{1 - \beta\gamma}}_{\textbf{Standard Term}} + \underbrace{\mu \frac{\sum_{T=t+1}^{\infty} (\beta\gamma)^{T-t} cov_t\left(mc_T, \frac{G_T}{G_t}\right)}{1 - \beta\gamma}}_{\textbf{Distortion due to Doubts}} \right]^{\theta - 1}.$$

Exogenous driving process and calibration

The technology frontier evolves over time according to

$$\log(A_t) = \zeta + \log(A_{t-1}) + \varepsilon_t, \qquad \varepsilon_t \quad \text{i.i.d. } N(0, \sigma_\varepsilon^2)$$

Parameter	Moment/Statistic Matched	Value
α	labor share of output	0.36
δ	capital depreciation rate	0.025
θ	average markup	6
η	inverse Frisch labor supply elasticity	0.45
γ	frequency of non-adjusting price	0.6
$\bar{\phi}''$	elasticity of investment ratio to Tobin's q	0.25
ζ	mean TFP growth	0.003
σ_ε^2	volatility TFP growth	0.012
β	average real interest rate	0.99
Ψ	equity premium/other values	{1, 25 ,50, 100 }

Planner's problem

- Planner trusts the (reference) model, knows private sector's beliefs.
- Two cases for policy objective:
  1. *"Paternalistic"* policy-maker

$$Max\ E_{t_0}\left\{\sum_{t=t_0}^{\infty}\beta^{t-t_0}U(C_t,L_t)\right\}$$

  2. *"Benevolent"* policy-maker

$$Max\ E_{t_0}\left\{G_t\sum_{t=t_0}^{\infty}\beta^{t-t_0}\left[U(C_t,L_t)+\kappa\beta E_t(g_{t+1}\ln g_{t+1})\right]\right\}$$

- Max objective under commitment subject to set of FOCs determining equilibrium allocations.

Four types of distortions

- Four distortions:
  - Monopolistic firms $\rightarrow$ positive s.s markup $\rightarrow$ lower s.s output.
  - Price rigidity $\rightarrow$ inefficient price dispersion/ markup variability.
  - Distorted beliefs $\rightarrow$ distorted price setting/capital accumulation.
  - Capital adjustment costs $\rightarrow$ inefficient investment dynamics.

Model uncertainty invariant to monetary policy at first order

- Permanent technology shocks have permanent effects on C, independently of monetary policy
- Dynamics in g_{t+1}dominated by long-run dynamics in C :

$$\begin{aligned}\hat{g}_{t+1} &\simeq -(\psi - 1)[(E_{t+1}\hat{C}_{\infty} - E_t\hat{C}_{\infty}) + \eta(E_{t+1}\hat{L}_{\infty} - E_t\hat{L}_{\infty})], \\ &\simeq -(\psi - 1)\ \epsilon_{t+1}.\end{aligned}$$

- Monetary policy neutral in the long-run, no substantial impact on g_{t+1}.

Figure: Paternalistic policy maker

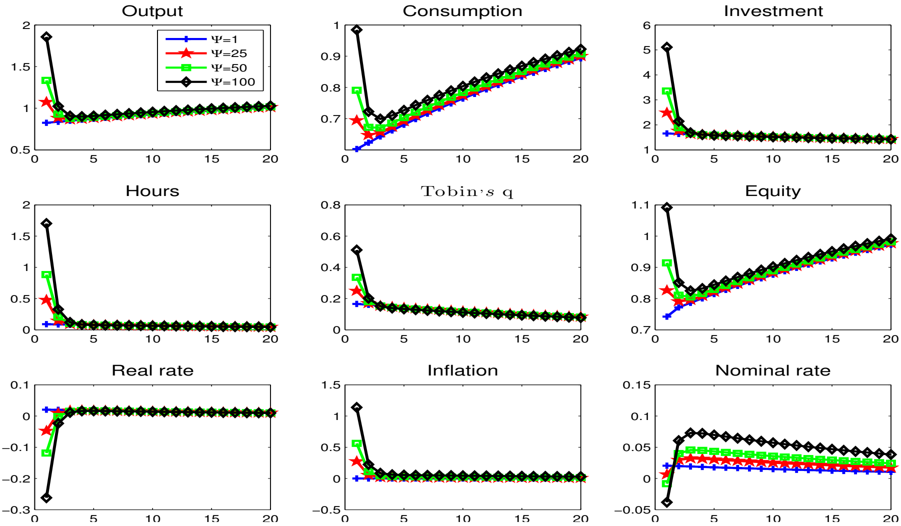
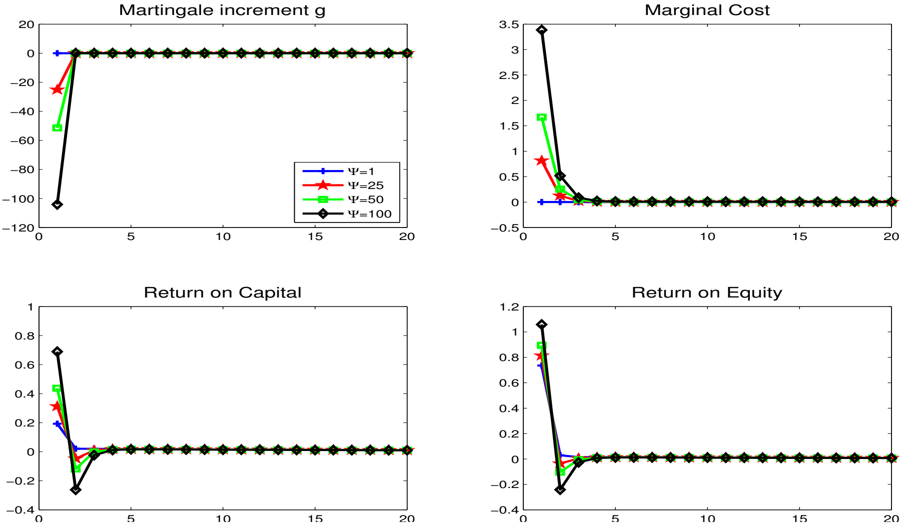


Figure: Paternalistic policy maker



Dynamics in g_t, monetary policy and price setting

- Optimal policy increases average output, reduces average markup:

$$\left(\frac{1-\gamma\Pi_t^{\theta-1}}{1-\gamma}\right) = \frac{p^*}{P_t} =$$

$$= \left[\mu\frac{\sum_{T=t}^{\infty}(\beta\gamma)^{T-t}E_t\left(mc_T\right)}{1-\beta\gamma} + \underbrace{\mu\frac{\sum_{T=t+1}^{\infty}(\beta\gamma)^{T-t}cov_t(mc_T,\frac{G_T}{G_t})}{1-\beta\gamma}}_{\mathbf{<0}}\right]^{\theta-1},$$

- Optimal policy increases the equity premium:

$$E_t\hat{r}_{t+1}^K - r_t^f + \frac{1}{2}Var_t\hat{r}_{t+1}^K = -cov_t(\hat{m}_{t,t+1},\hat{r}_{t+1}^K)\underbrace{-cov_t(\hat{g}_{t+1},\hat{r}_{t+1}^K)}_{\mathbf{>0}}$$

The role of doubts

- Means of selected variables:

	Paternalistic	Inflation targeting
Consumption	**1.68**	**1.58**
Investment	**0.52**	**0.42**
Hours	0.62	0.60
Markup	1.15	1.20
Inflation*	**0.00**	**0.00**
Capital Prem.*	2.90	0.01
Equity Prem.*	4.40	0.02

Table: $\psi = 100$; *= in % and at annual rates

- The presence of doubts reduces average markup, increases average output, consumption, investment..

An illustration of the main mechanism

Let $\mu_c = E[c_t - c_t^*]$, $\sigma_c^2 = E[(c_t - c_t^*)^2]$, $\mu_\pi = E[\pi_t - \pi_t^*]$, $\sigma_\pi^2 = E[(\pi_t - \pi_t^*)^2]$.

- S.O. approximation to welfare loss in neighbor of s.s depends on:

  $$a_1 \mu_c + a_2 \sigma_c^2 + a_3 \mu_\pi + a_4 \sigma_\pi^2 + ...,$$

  with $a_1 < 0$, $a_2 > 0$, $a_3 > 0$ and $a_4 > 0$.
- In the standard REH model, equilibrium dynamics are s.t.:

  $$\mu_c = f(\mu_\pi, \sigma_\pi^2, \sigma_{\pi c^*}, ...), \qquad \sigma_c^2 = g(\sigma_\pi^2, \sigma_{\pi c^*}, ...),$$

  trade-off between μ_c and σ_c^2, σ_π^2, but "slope" of function $f(\cdot)$ is "small".
- In the model with doubts, equilibrium dynamics are s.t.:

  $$\mu_c = \tilde{f}(\mu_\pi, \sigma_\pi^2, \sigma_{\pi c^*}, ...), \qquad \sigma_c^2 = \tilde{g}(\sigma_\pi^2, \sigma_{\pi c^*}, ...),$$

  trade-off between μ_c and σ_c^2, σ_π^2, but "slope" of function $\tilde{f}(\cdot)$ is "large": $\sigma_{\pi c^*} > 0, \sigma_\pi^2 > 0$ implies larger σ_c^2 as before, but mch larger μ_c.

The benevolent policymaker

- Same transmission of paternalistic case....
- ..but different objective:

$$Max\ E_{t_0}\left\{\sum_{t=t_0}^{\infty}\beta^{t-t_0}\mathbf{G}_t\left[U(C_t,L_t)+\kappa\beta E_t(g_{t+1}\ln g_{t+1})\right]\right\}$$

that can be roughly expressed as

$$Max\ \underbrace{\sum_{t=t_0}^{\infty}\beta^{t-t_0}E_{t_0}[U(C_t,L_t)]}_{Paternalistic\ objecitve}+\underbrace{\sum_{t=t_0}^{\infty}\beta^{t-t_0}cov_{t_0}[U(C_t,L_t);G_t]}_{Term\ due\ to\ distorted\ beliefs}$$

where due to the second term a more pro-cyclical policy reduces welfare.

Figure: Benevolent policy maker

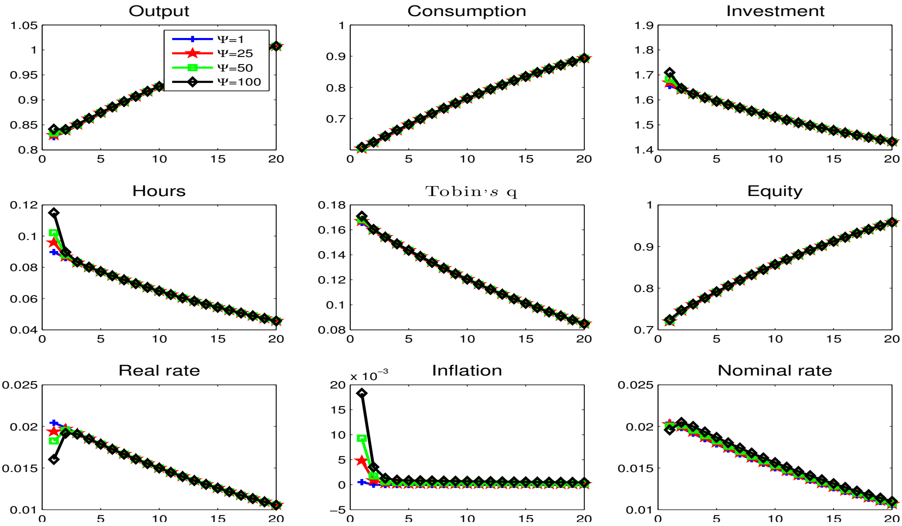


Figure: Benevolent policy maker

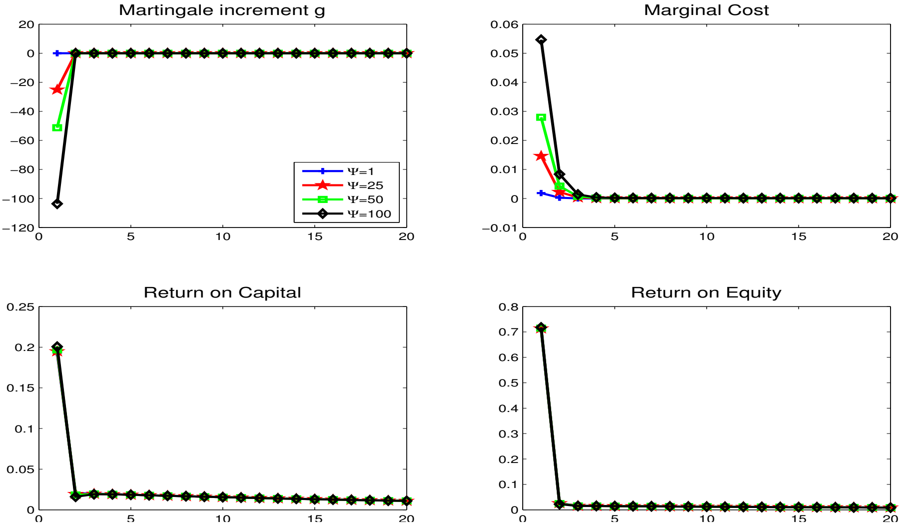
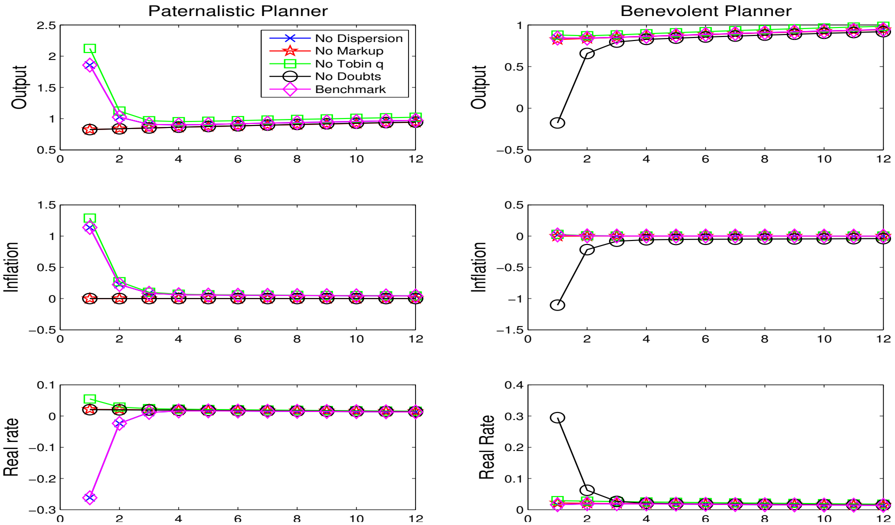


Figure: The role of the different distortions



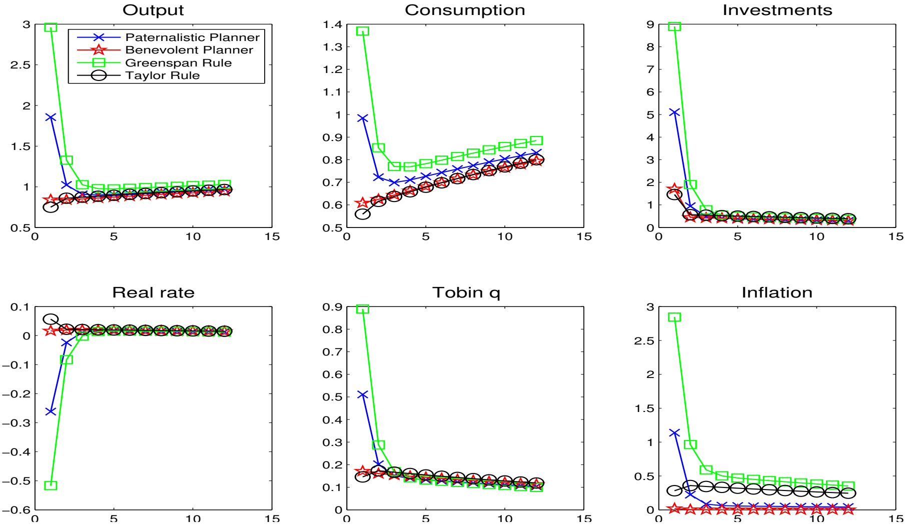
Interest rate rules vs Ramsey policy

- How does the paternalistic/benevolent optimal policy compare to Greenspan policy or Taylor rule?
- We consider a model where monetary policy follows an interest rate rule:

$$\ln\left(\frac{R_t^f}{\bar{R}^f}\right) = \rho_r \ln\left(\frac{R_{t-1}^f}{\bar{R}^f}\right) + (1-\rho_r)\left(\phi_\pi \ln\frac{\Pi_t}{\bar{\Pi}} + \phi_y \ln\frac{Y_t}{Y_t^*}\right),$$

- We consider two parametrizations:
  - Standard Taylor rule: $\rho_r = 0$, $\phi_\pi = 1.5$, $\phi_y = 0.5$.
  - Estimated rule in the Greenspan's tenure: $\rho_r = 0.9$, $\phi_\pi = 1.01$, $\phi_y = 0.75$.

Figure: Interest rate rules vs Ramsey policy



Extensions and concluding remarks

Other results:

- Responding directly to asset price fluctuations does not substantially improve welfare

Conclusions:

- Accounting for model uncertainty may change optimal monetary policy in a substantial way
- Monetary policy very accommodative to productivity shock, inflating equity premium
- Asset price movements improve the output-inflation trade-off.
- Strict inflation targeting not always optimal
- Distinction between Paternalistic and Benevolent policymakers quantitatively important

Ellsberg paradox

- Urn A: 100 balls, red and black in unknown proportion
- Urn B: 100 balls, red and black in equal proportion
- Most people indifferent between betting on red and black when facing Urn A.
- Most people indifferent between betting on red and black when facing Urn B.
- Most people strictly prefer betting on red from Urn B than on red from Urn A. back