Monetary Policy and the Equity Premium

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Motivation

- Monetary policy affects the macroeconomy primarily through financial markets.
- Two possible channels:
  - Monetary policy affects the (*unconditional mean of the)* real rate, which in turn affects real economy.
  - Monetary policy affects economic risk (*conditional variances*).
- Standard models (i.e. CIA and NK) abstract from the second channel.
- Evidence that economic risk is important in accounting for asset prices.
- We develop a DSGE model with both channels to explain the response of equity prices to monetary shocks.

Sluggish Portfolio Rebalancing

- We extend the neoclassical CIA model to allow for **segmented** goods and asset markets.
- **Fixed costs** of transferring funds from a brokerage to a checking account.
- Households only **infrequently** update their desired allocation of cash across these two accounts. Households are **heterogenous in their fixed cost** of transferring funds.
- Recent micro evidence on household finance provides strong support for *infrequent portfolio rebalancing* with considerable heterogeneity across households.
  - *Brunnermeier & Nagel* (2008) and *Haliassos et al*. (2008)
  - *Calvet, Campbell, and Sodini (2008, 2009)*

Monetary Policy and Stock Prices

- Using high frequency data *Bernanke & Kuttner (2005)* show that:

1. Stock prices rise 1 percent to a 25 bp surprise in federal funds rate.
2. An important part of the increase is due to changes in equity premia.

- Standard models can not capture the second fact.
- We show that a model with infrequent portfolio rebalancing can account for this evidence.

Related Literature

- Alvarez, Atkeson, Kehoe (2007) emphasize *endogenous participation* in financial markets to account for time-varying risk in exchange rates.
  - We differ by emphasizing the endogenous asset segmentation along an *intensive* margin (i.e. rebalancing) rather than the *extensive* margin (i.e. participation).
- Abel, Eberly, and Panageas (2007) study infrequent adjustment of funds between assets and goods markets in a partial equilibrium setting with rational inattention.
  - We study monetary policy in a general equilibrium framework.

Model Overview

- Agents:(i) households, (ii) firms, and (iii) the government.
- In $t = 0$, there is trade in asset markets, and no trade in goods markets.
- In $t \geq 1$,
  - In the *asset markets*, households trade a complete set of state-contingent claims and equity in the firms.
  - In the *goods markets*, households use money to buy goods subject to a CIA constraint.
- There are two sources of uncertainty: aggregate shocks to technology, z_t, and to money growth, μ_t.
- We index the states at date t by $s_t = (z_t, \mu_t)$, and $s^t = (s_1, ..., s_t)$ denote history through period t.

Market Segmentation

- At date $t = 0$, households decide on a costless, *non-state contingent* amount of cash to transfer from assets to goods markets in periods $t \geq 1$.
- The initial non-state-contingent allocation plan (i.e., the annuity) ensures that all agents participate in financial markets.
- At $t \geq 1$, make *state-contingent* transfers between these markets, households pay a *fixed cost*.
  - This cost is constant over time but varies across households.
  - If pays this cost, HH actively *rebalances* portfolio. If not, then inactive.

Firms

- Technology:

$$Y(s^t) = K(s^{t-1})^\alpha \left[\exp(z_t)L(s^t)\right]^{1-\alpha},$$

  with $z_t = \rho_z z_{t-1} + \epsilon_{zt}$, and $\epsilon_{zt} \sim N(0, \sigma_z^2)$.
- Firms have a one-period planning horizon. To operate capital in period $t+1$, a firm must purchase it by issuing equity.
- In equilibrium:

$$\begin{aligned} w(s^{t+1}) &= (1-\alpha)\frac{Y(s^{t+1})}{L(s^{t+1})}, \\ 1 + r^e(s^{t+1}) &= \frac{\left[\alpha \frac{Y(s^{t+1})}{K(s^t)} + p_k(s^{t+1})\right]}{p_k(s^t)} \end{aligned}$$

- Fixed factor supply: $K(s^t) = 1,\ L(s^t) = 1$

Government

- Issues one-period state-contingent bonds and controls the economy's money stock, M_t.
- At date $t = 0$, the government also *issues an annuity at price*, P_A, *which has a constant payoff* A_0 in units of consumption.
- Budget constraints at date $t = 0$:

$$\bar{B} = \int_{s_1} q(s_1)B(s_1)ds_1 + P_A A_0,$$

  $\bar{B}$ is given, $q(s_1)$ is the price of the state-contingent bond, $B(s_1)$.
- At dates $t \geq 1$, the government's budget constraint:

$$B(s^t) + M_{t-1} + P(s^t)A_0 = M_t + \int_{s_{t+1}} q(s^t, s_{t+1})B(s^t, s_{t+1})ds_{t+1},$$

- Finally, the government injects cash:

$$\frac{M_t}{M_{t-1}} = \mu_t = (1 - \rho_\mu)\bar{\mu} + \rho_\mu \mu_{t-1} + \epsilon_{\mu t}, \quad \epsilon_{\mu t} \sim N(0, \sigma_\mu^2).$$

Households' Fixed Costs

- A household can purchase and sell bonds and stocks in asset markets.
- Asset and goods markets are segmented, so that a household must pay a real fixed cost, γ, to transfer cash between them. Hence, **households are indexed** by γ.
- This cost is constant for a household but differs across households according to the distribution $F(\gamma)$ with density $f(\gamma)$.

Households and Cash in the Goods Market

- CIA in goods market for household γ:

$$P(s^t)c(s^t,\gamma) = M(s^{t-1},\gamma) + P(s^t)A(\gamma) + P(s^t)x(s^t,\gamma)z(s^t,\gamma).$$

- At dates $t \geq 1$, HH receives a non-state contingent transfer of cash, $A(\gamma)$, from the annuity purchased at date $t = 0$.
- Households pay fixed cost γ of making state contingent transfer, $x(s^t,\gamma)$, between checking and brokerage accounts.
- If HH pays fixed cost γ, then $z(s^t,\gamma) = 1$.

  $z(s^t,\gamma) = 0$, otherwise.

Households and Cash in Asset Markets

- HH with different fixed costs of transferring $x(s^t, \gamma)$ will demand different $A(\gamma)$.
- Through the choice of $A(\gamma)$, all HHs participate in financial markets.
  - If HH cannot make non-state contingent transfers (i.e., $A(\gamma) = 0$), there is limited participation in asset markets (AAK (2007)).
- Household cash constraint in asset markets at dates $t \geq 1$:

$$B(s^t, \gamma) + (1 + R^e(s^t)) S(s^{t-1}, \gamma) = \int_{s_{t+1}} q(s^t, s_{t+1}) B(s^t, s_{t+1}, \gamma) ds_{t+1} + S(s^t, \gamma) + P(s^t) [x(s^t, \gamma) + \gamma] z(s^t, \gamma).$$

Households Utility

- Households maximize:

$$\sum_{t=1}^{\infty} \beta^t \int_{s^t} U(c(s^t, \gamma))g(s^t)ds^t$$

whith $g(s^t)$ denotes the probability distribution over history s^t, and:

$$U(c) = \frac{c^{1-\sigma} - 1}{1 - \sigma}$$

Households Budget Constraint

- Household budget constraint simplifies to:

$$M(s^t, \gamma) = P(s^t) w(s^t)$$

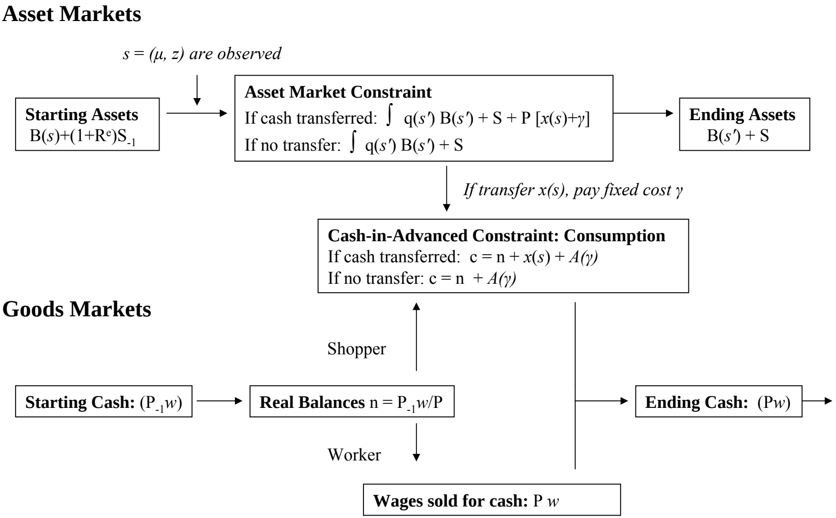
- Beginning of period cash is independent of γ.
- This requires:

$$\int_{s_{t+1}} \beta \frac{U'[c(s^{t+1}, \gamma)]}{U'[c(s^t, \gamma)]} \frac{P(s^t)}{P(s^{t+1})} g(s_{t+1}) ds_{t+1} < 1$$

- For HHs that always rebalance, this implies:

$$R(s^t) > 1$$

Timing in the Two Markets



Characterizing Equilibrium Allocations

- Consumption of *inactive rebalancers*:

$$c_I(s^t, \gamma) = \frac{w(s^t)}{\mu_t} + A(\gamma)$$

- Complete risk-sharing among *active rebalancers*:

$$c_A(s^t, \gamma) = c_A(s^t), \;\; \forall\, \gamma$$

- HH annuity provides insurance for inactive types:

$$\sum_{t=1}^{\infty} \beta^t \int_{s^t} \left[U'(c_A(s^t)) - U'(c_I(s^t, \gamma)) \right] (1 - z(s^t, \gamma)) g(s^t) ds^t = 0.$$

- To get proceeds from equity, inactive types set $A(\gamma) \geq 0$.

The Marginal Rebalancer

- $\bar{\gamma}(s^t)$ is the fixed cost of the marginal rebalancer determined by:

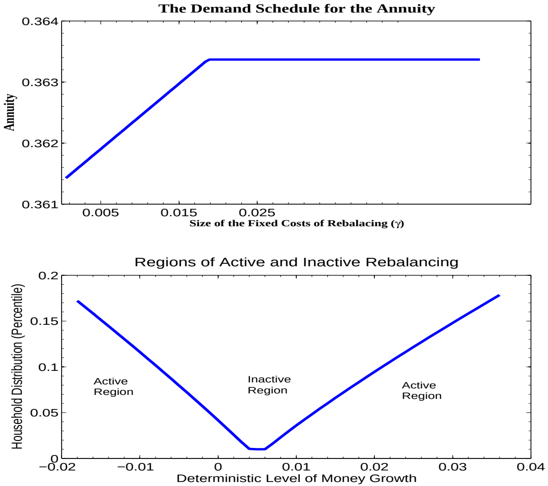
$$U[c_A(s^t)]\text{-}U[c_I(s^t,\bar{\gamma}(s^t))]=U'[c_A(s^t)]\left[c_A(s^t)\text{-}c_I(s^t,\bar{\gamma}(s^t))+\bar{\gamma}(s^t)\right],$$

- where $c_I(s^t,\bar{\gamma}(s^t)) = \frac{w(s^t)}{\mu_t}+A(\bar{\gamma}(s^t))$.
- Consumption of rebalancers is given by:

$$F(\bar{\gamma}(s^t))c_A(s^t)+\int_{\bar{\gamma}(s^t)}^{\infty}[\frac{w(s^t)}{\mu_t}+A(\gamma)]f(\gamma)d\gamma=Y(s^t)\text{-}\int_0^{\bar{\gamma}(s^t)}\gamma f(\gamma)d\gamma,$$

where $F(\gamma)$ and $f(\gamma)$ are the cdf and pdf of γ: $\log\gamma \sim N(\widetilde{\gamma}_m,\sigma_\gamma^2)$.

State-dependent Rebalancing



Consumption of Rebalancers and Asset Pricing

- Pricing kernel depends on the consumption of rebalancers:

$$m(s^t, s_{t+1}) = \beta \left[\frac{c_A(s^t)}{c_A(s^{t+1})} \right]^{\sigma}$$

- Risk-free rate:

$$[1 + r_t^f]^{-1} = \mathrm{E}_t m_{t,t+1}$$

- Return on equity:

$$1 + r_{t+1}^e = \frac{[\alpha \exp[(1-\alpha) z_{t+1}] + p_{k,t+1}]}{p_{k,t}}$$

- The equity premium:

$$1 + r_t^{ep} = \frac{\mathrm{E}_t [1 + r_{t+1}^e]}{1 + r_t^f} = 1 - \mathrm{cov}_t \left(\beta \left[\frac{c_{A,t}}{c_{A,t+1}} \right]^{\sigma}, 1 + r_{t+1}^e \right)$$

Global Model Solution

- Given $A(\gamma)$, the resource constraint and equilibrium condition for the marginal rebalancer determine $c_A(s^t)$ and $\bar{\gamma}(s^t)$.

- Following Tauchen and Hussey (1991) and Judd (1998), we use the *linear Fredholm integral equations (Type 2)* and *quadrature* to determine the price of capital from the stochastic difference equation:

$$p_k(s^t) = \int_{s_{t+1}} m(s^t, s_{t+1}) \left[\alpha \exp[(1-\alpha)z_{t+1}] + p_k(s^{t+1})\right] g(s_{t+1}|s^t) ds_{t+1}$$

- Similar approach to determine $A(\gamma)$ for a fixed value of γ. Then $A(\gamma)$ is approximated using piecewise linear interpolation.

Calibration

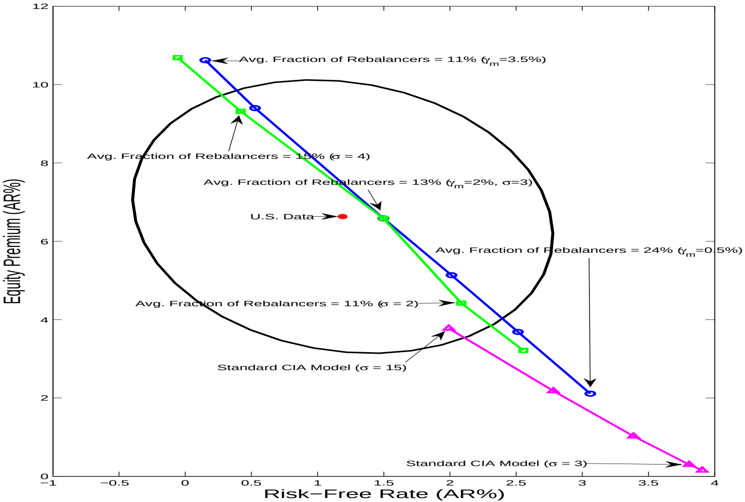
Parameter	Values
β	0.99
α	0.36
σ	3
γ_m	0.02
σ_γ	0.35

Parameter	Values
μ	1.04
ρ_z	0.97
$\sigma_z(\%)$	1.3
ρ_μ	0.9
$\sigma_\mu(\%)$	0.7

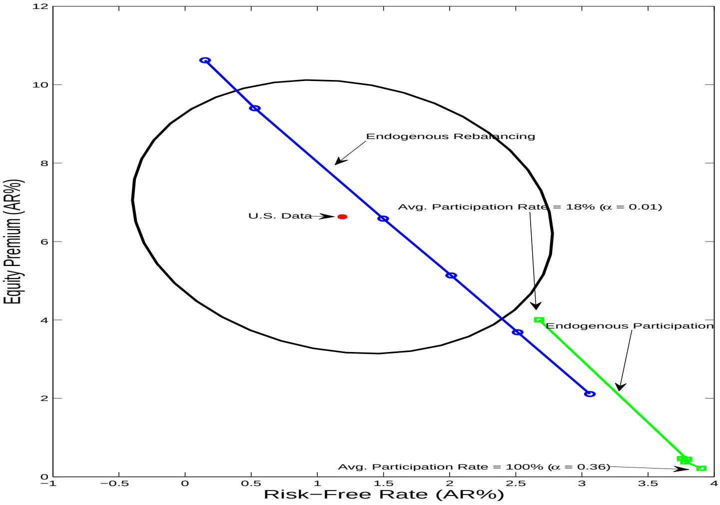
Deterministic Steady State

- The endogenous rebalancing model reduces to a representative agent model:
$$c_A = c_I = (1-\alpha)\mu^{-1} + A$$
- The model only becomes interesting in the presence of uncertainty.
- The endogenous participation model (*strong incentive to participate*):
$$c_A > c_I (= (1-\alpha)\mu^{-1})$$

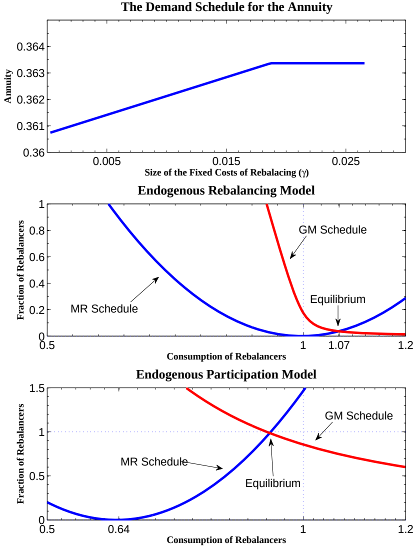
Endogenous Rebalancing and the Equity Premium



Endogenous Participation



Understanding the Mechanism



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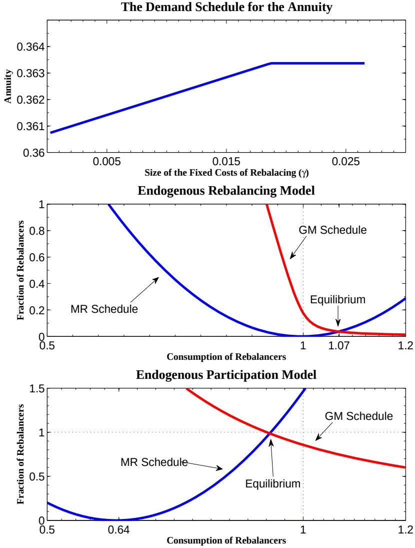

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- Insurance against consumption losses

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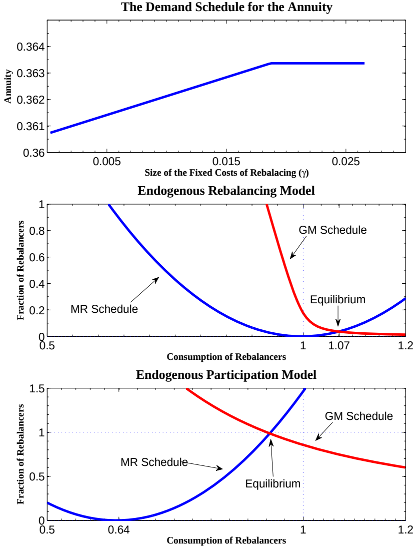

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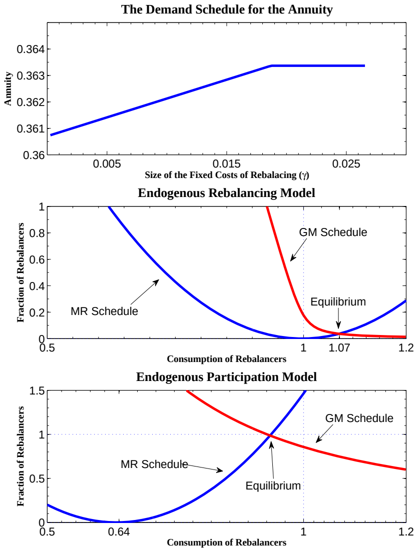

- Higher γ $\Rightarrow$less frequency$\Rightarrow$Higher demand A
- Insurance against consumption losses
- Understanding the mechanism $(A(\gamma) \cong A)$
- GM schedule:

$$\frac{\bar{\gamma} c_A}{\gamma_u} + \left(1 - \frac{\bar{\gamma}}{\gamma_u}\right) c_I = e^{[(1-\alpha)z]} - \frac{\bar{\gamma}^2}{2\gamma_u}$$

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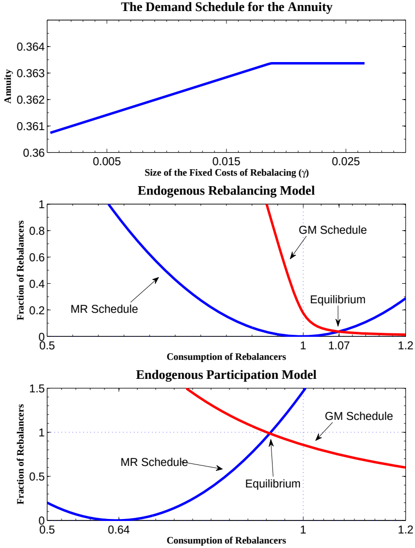

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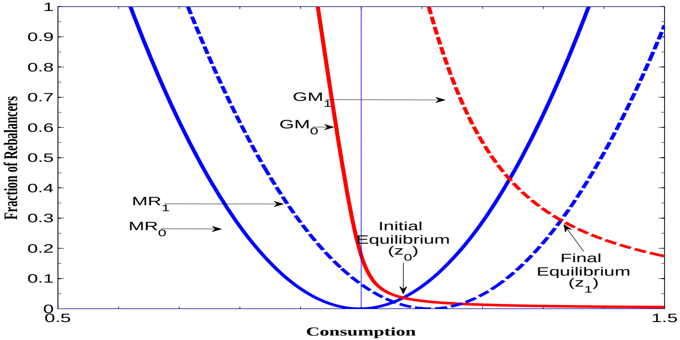
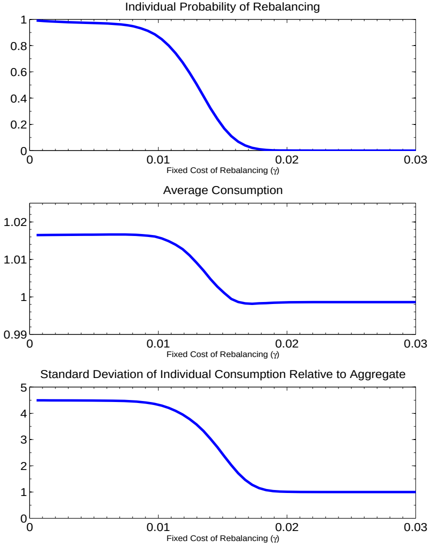
- MR schedule:

$$(c_A - c_I)^2 = c_I \bar{\gamma},\ c_I = (1-\alpha)\mu^{-1} + A$$

A Technology Improvement

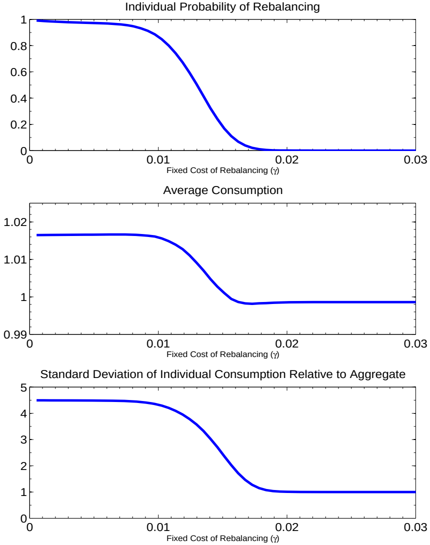


Individual Heterogeneity



- Heterogeneity in portfolio rebalancing, with a large fraction showing inertia.

Individual Heterogeneity



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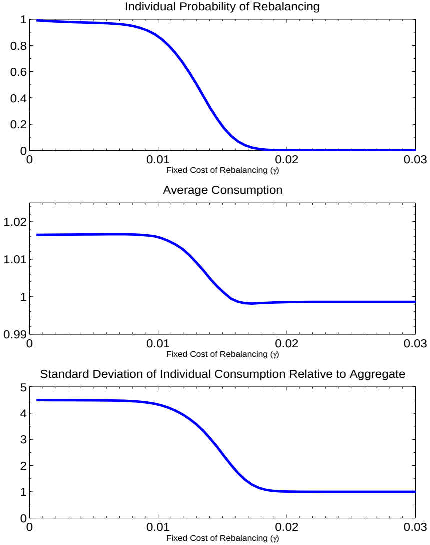


- Heterogeneity in portfolio rebalancing, with a large fraction showing inertia.
- HH are trading off consumption volatility against higher average consumption.
- Higher volatility of c_A translates into high return on equity.

Monetary Policy and Equity Prices: Bernanke-Kuttner

- They find that a broad index of stock prices registers a one-day gain of 1 percent in reaction to a 25 basis point easing of the federal funds rate.
- They decompose the response of stock prices into three components:
  - Current and expected changes in the real rate
  - Expected future excess equity returns or equity premia
  - Current and expected changes in dividends,
- They conclude that an important channel by which stock prices increase occurs through changes in the equity premium.

Impulse Response to a Monetary Policy Shock

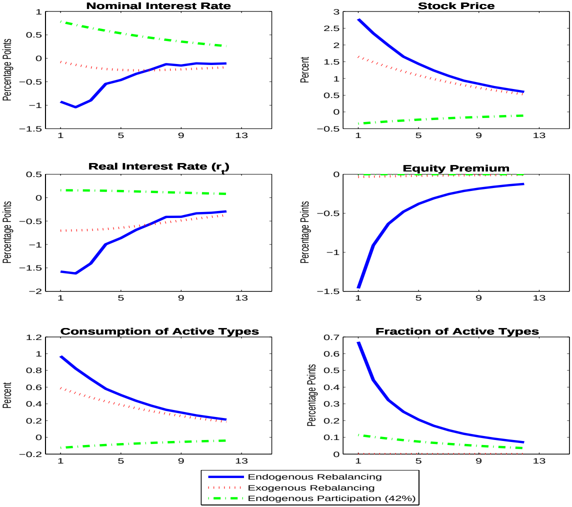
- An IRF of $y(s^t)$ to μ_1 is defined as the revision in expectations from a variable's conditional mean (Hamilton (1994)):

$$E[log\left(y(s^t)\right) \mid \mu_1, z_0] - E[log\left(y(s^t)\right) \mid \mu_0, z_0]$$

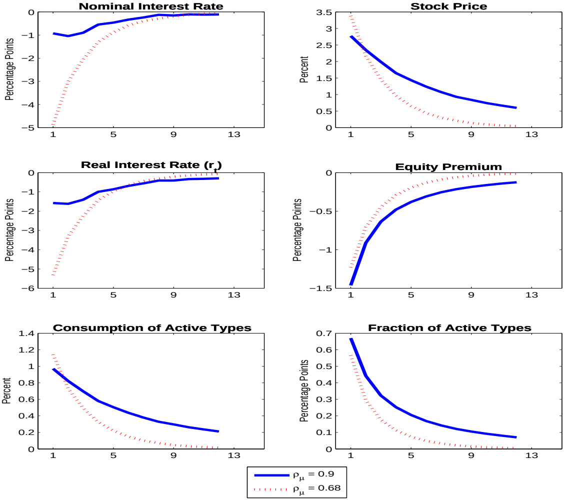
where $\mu_0 = \bar{\mu}$ and $z_0 = \bar{z}$.

- We use *Monte Carlo integration* to compute the conditional expectation, which involves multidimensional integrals.

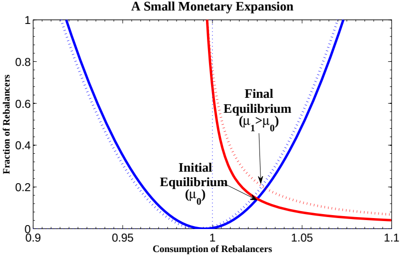
IRFs to a Money Growth Shock

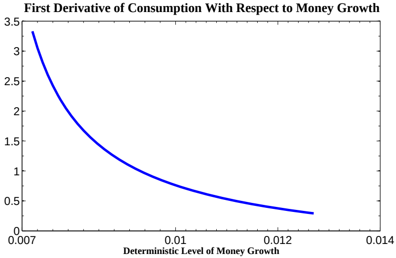


IRFs to a Money Growth Shock (cont.)



Why Does a Monetary Expansion Lower Risk?





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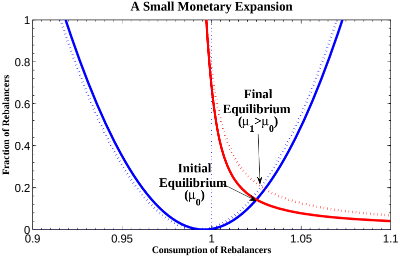

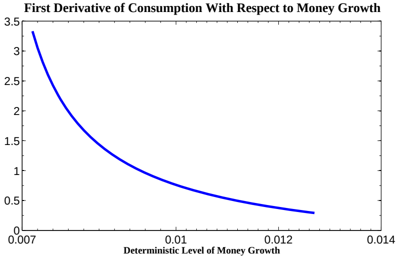

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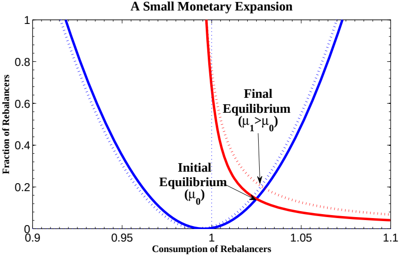

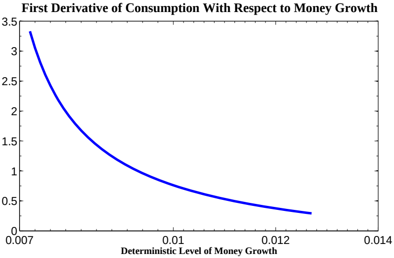

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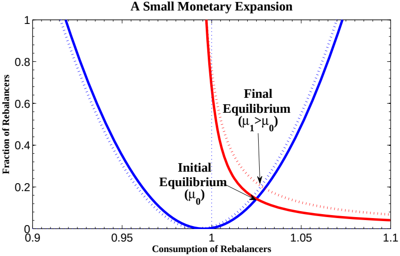
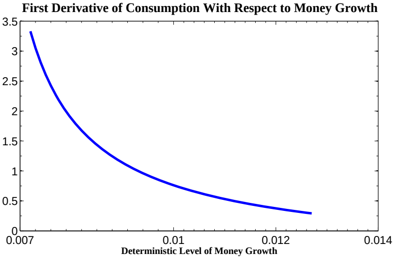
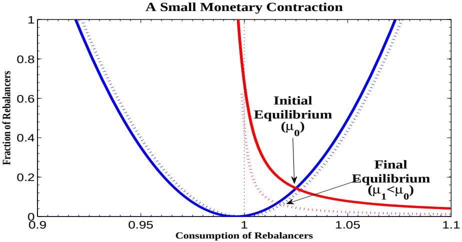
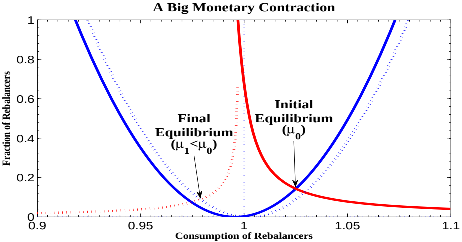




- Higher μ $\Rightarrow$higher c_A and $\frac{\bar{\gamma}}{\gamma_u}$.
- Final Equilibrium$\Rightarrow$less volatile c_A. Translates into lower equity premium.
- Lower volatility because $\frac{\bar{\gamma}}{\gamma_u}$ is higher. In the limit, as $\frac{\bar{\gamma}}{\gamma_u} \to 1$, c_A is unaffected by μ.
- Changes in risk reflect that c_A is increasing and concave in μ.

A Reduction in Money Growth





Conclusion and Further Research

- We have developed a DSGE model with infrequent portfolio rebalancing where monetary policy affects the economy through changes in risk.
- The model is helpful in accounting for the average equity premium and the response of the equity prices to monetary policy shocks.
- Future research:
  - Feedback from changes in risk to the policy instrument.
  - Endogenous capital and labor supply to jointly analyze asset prices and business cycles.
  - Address how endogenous movements in risk affect optimal monetary policy.