A Model of Monetary Policy and Risk Premia

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Monetary policy and risk premia

1. Textbook model of monetary policy (e.g. New Keynesian)
   - nominal rate affects real interest rate through sticky prices
   - largely silent on *risk premia* (can have indirect effects given balance sheet constraints)

2. Yet lower nominal rates decrease risk premia
   - higher equity valuations, compressed credit spreads ("yield chasing")
   - increased leverage by financial institutions

3. Today's monetary policy directly targets risk premia
   - "Greenspan put", Large-Scale Asset Purchases, "Operation Twist"

$\Rightarrow$ We build a dynamic equilibrium asset pricing framework in which monetary policy affects risk taking and risk premia

Model overview

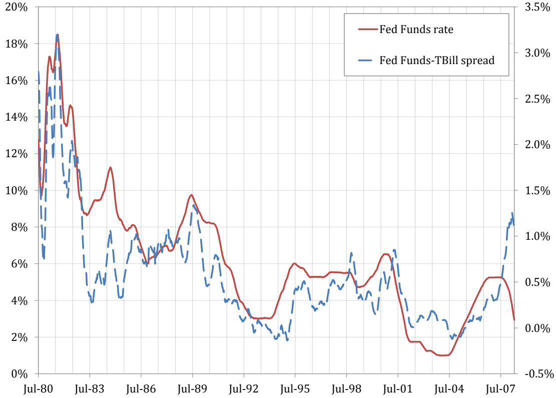
1. Central bank sets nominal rate to regulate economy's effective risk aversion by changing banks' cost of leverage

2. Endowment economy, 2 agent types
   - low risk aversion: pool wealth as equity capital of "banks"
   - high risk aversion "depositors"
   - banks take leverage by issuing risk-free deposits
   - must hold fractional reserves against deposits
     - $\Rightarrow$ imposes a cost on taking leverage
       - rationale: contain externalities due to deposit insurance/fire sales
   - no nominal price rigidities

3. Central bank controls cost of holding reserves (= nominal rate)
   - when nominal rate falls, leverage becomes cheaper
     - $\Rightarrow$ bank risk taking rises
     - $\Rightarrow$ risk premia and cost of capital fall
   - we solve for reserve dynamics that implement nominal rate policy

Essential mechanism

1. Nominal rate affects banks' *external finance spread*
   = Fed Funds rate − risk-free bond rate
   - We obtain this via reserves, an asset-side cost
   - Also work out a liabilities-side channel where the nominal rate affects the spread banks earn on deposits liabilities-side channel



Related literature

1. **"Credit view" of monetary policy:** Bernanke and Gertler (1989); Kiyotaki and Moore (1997); Bernanke, Gertler, and Gilchrist (1999); Gertler and Kiyotaki (2010); Curdia and Woodford (2009); Adrian and Shin (2010); Brunnermeier and Sannikov (2013)
2. **Bank lending channel:** Bernanke and Blinder (1988); Kashyap and Stein (1994); Stein (1998); Stein (2012)
3. **Government liabilities as a source of liquidity:** Woodford (1990); Krishnamurthy and Vissing-Jorgensen (2012); Greenwood, Hanson, and Stein (2012)
4. **Empirical studies of monetary policy and asset prices:** Bernanke and Blinder (1992); Bernanke and Gertler (1995); Kashyap and Stein (2000); Bernanke and Kuttner (2005); Gertler and Karadi (2013); Hanson and Stein (2014); Landier, Sraer, and Thesmar (2013); Sunderam (2013)
5. **Asset pricing with heterogeneous agents:** Dumas (1989); Wang (1996); Longstaff and Wang (2012)
6. **Margins and asset prices:** Gromb and Vayanos (2002); Geanakoplos (2003, 2009); Brunnermeier and Pedersen (2009); Garleanu and Pedersen (2011)

Setup

1. Aggregate endowment: $dD_t/D_t = \mu_D dt + \sigma_D dB_t$
2. Two agent types: A is risk tolerant, B is risk averse:

$$U^A = E_0\left[\int_0^\infty f^A(C_t, V_t^A)\,dt\right] \quad \text{and} \quad U^B = E_0\left[\int_0^\infty f^B(C_t, V_t^B)\,dt\right]$$

   - $f^i(C_t, V_t^i)$ is Duffie-Epstein-Zin aggregator
   - $\gamma^A < \gamma^B$ creates demand for leverage (risk sharing)

3. State variable is the wealth share of A agents:

$$\omega_t = \frac{W_t^A}{W_t^A + W_t^B}$$

   - View ω_t as risk-tolerant wealth pooled into bank capital

Financial assets

1. Risky asset is a claim to D_t with return process

$$dR_t = \mu(\omega_t)\, dt + \sigma(\omega_t)\, dB_t$$

2. Instantaneous risk-free bonds (deposits) pay $r(\omega_t)$, the real rate

3. Banks must hold *reserves* in proportion to their deposits
   - $w_{S,t}$ = risky asset portfolio share
   - $w_{M,t}$ = reserves portfolio share

$$w_{M,t} \geq \max\left[\lambda\sigma_t^2 (w_{S,t} - 1), 0\right]$$

   - scaling by σ_t^2 is for analytical simplicity only
   - only central bank can create reserves (cannot be shorted)

4. Central bank adds/removes reserves from circulation by buying/selling bonds, i.e. open market operations

Central bank policy

1. There are M_t reserves. The central bank sets μ_M and σ_M in

$$\frac{dM_t}{M_t} = \mu_M(\omega_t)\,dt + \sigma_M(\omega_t)\,dB_t$$

2. Each \$ of reserves is worth π_t consumption units. We take reserves as the numeraire, so π_t is the inverse price level.
   - For simplicity, we have the central bank choose dM_t/M_t so that inflation is locally deterministic:

$$-\frac{d\pi_t}{\pi_t} = i(\omega_t)dt$$

3. Define the nominal rate

$$n(\omega_t) = r(\omega_t) + i(\omega_t)$$

   - $n(\omega_t)$ is the central bank's policy, which agents know

4. Central bank refunds its seignorage profits ($\pi_t M_t n_t dt$) to agents in proportion to their wealth

Optimization

1. HJB equation for each agent type is:

$$0 = \max_{c, w_S, w_M} \; f(cW, V)dt + E\left[dV\left(W, \omega\right)\right]$$

subject to

$$\begin{aligned} w_M &\geq \max\left[\lambda\sigma^2\left(w_S - 1\right), 0\right] \\ \frac{dW}{W} &= \left[r - c + w_S\left(\mu - r\right) + w_M \underbrace{\left(\frac{d\pi}{\pi} - r\right)}_{= \; -n} + Gn\right]dt + w_S \sigma dB \end{aligned}$$

- $-n$ is the excess return on reserves
- Gn is rate of seignorage payment per unit of wealth, G is the wealth share of reserves

Optimality conditions

1. Each agent's value function has the form

$$V\left(W,\omega\right)=\rho^{\frac{1-\gamma}{1-1/\psi}}\left(\frac{W^{1-\gamma}}{1-\gamma}\right)J\left(\omega\right)^{\frac{1-\gamma}{1-\psi}}$$

2. The FOC for consumption gives $c^{*}=J$

3. If $\lambda n<\gamma^{B}-\gamma^{A}$, the portfolio FOCs give

$$w_{S}^{A}=\frac{1}{\gamma^{A}}\left[\frac{\mu-r}{\sigma^{2}}-\lambda n+\left(\frac{1-\gamma^{A}}{1-\psi^{A}}\right)\frac{J_{\omega}^{A}}{J^{A}}\omega\left(1-\omega\right)\frac{\sigma_{\omega}}{\sigma}\right]$$

   and $w_{s}^{A}>1$
   - $\Rightarrow$ raising n increases the cost of leverage
   - $\Rightarrow$ reduces risk taking w_{S}^{A}
   - $\Rightarrow$ increases risk premia (effective risk aversion)

4. If $\lambda n\geq\gamma^{B}-\gamma^{A}$, $w_{S}^{A}=w_{S}^{B}=1\Rightarrow$ financial autarky

Fed Funds and the external finance spread

1. There is no reserve requirement on Fed Funds, so the Fed Funds rate is $r + \lambda\sigma^2 n$

2. $\lambda\sigma^2 n$ is the Fed Funds-risk-free bond (Tbill) spread
   - this is the premium banks pay for external funds
   - can rewrite banks' FOC as an unconstrained portfolio choice:

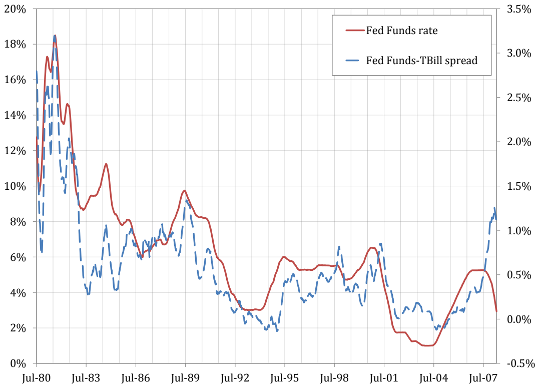
$$w_S^A = \frac{1}{\gamma^A}\left[\frac{\mu - \overbrace{\left(r + \lambda\sigma^2 n\right)}^{\text{Fed Funds rate}}}{\sigma^2} + \left(\frac{1-\gamma}{1-\psi}\right)\frac{J_\omega^A}{J^A}\omega\left(1-\omega\right)\frac{\sigma_\omega}{\sigma}\right]$$

$\Rightarrow$ Central bank regulates risk taking by influencing the external finance spread through n

3. The same expression arises under the liabilities-side channel

liabilities-side channel

Empirical relationship



20-week moving averages

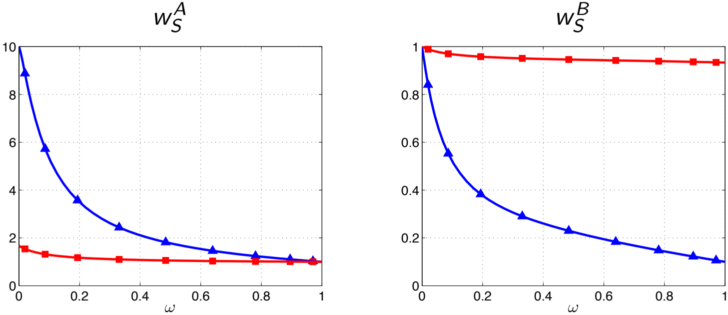
1. 86% correlation
2. Average spread is 57bps
   - for comparison, Moody's Baa-Aaa spread averages 1.07% in this period

Results

1. Solve HJB equations simultaneously for $J^A(\omega)$ and $J^B(\omega)$
2. Global solution by Chebyshev collocation

Risk aversion A	γ^A	1.5
Risk aversion B	γ^B	15
EIS	ψ^A, ψ^B	3.5
Endowment growth	μ_D	0.02
Endowment volatility	σ_D	0.02
Time preference	ρ	0.01
Reserve requirement	$\lambda\sigma_D^2$	0.1
Nominal rate 1	n_1	0%
Nominal rate 2	n_2	5%

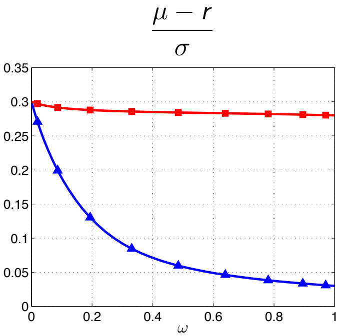
Risk taking

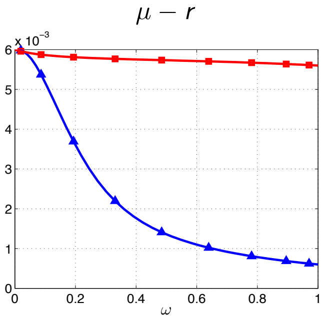


$\mathbf{n_1 = 0\%}$
$\mathbf{n_2 = 5\%}$

1. As the nominal rate increases, bank leverage falls and depositor risk taking increases
   - increases effective risk aversion of marginal investor

The price of risk and the risk premium

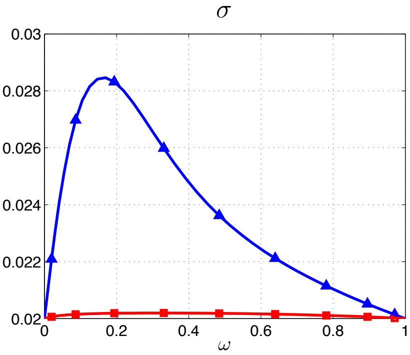




$\mathbf{n_1 = 0\%}$
$\mathbf{n_2 = 5\%}$

1. As nominal rate falls, the price of risk falls
2. Risk premium shrinks ("reaching for yield")
   - effect is larger for riskier assets

Volatility

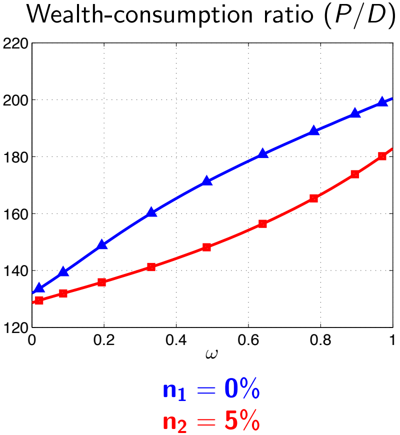


$\mathbf{n_1 = 0\%}$

$\mathbf{n_2 = 5\%}$

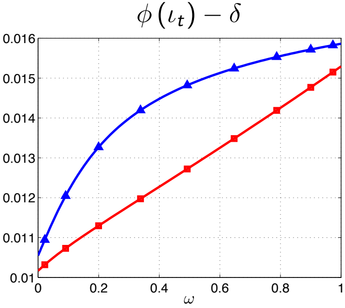
1. There is greater excess volatility at lower nominal rates due to more volatile discount rates
   - ω more volatile because leverage is higher
   - also risk premium more sensitive to ω variation

The cost of capital



1. Lower rates increase valuations for all ω
   - effect is largest for moderate ω, where aggregate risk sharing/leverage is at its peak
2. With production this leads to increased investment

Production



1. Incorporate production and capital accumulation subject to adjustment costs (ϕ):

$$\frac{dk_t}{k_t} = [\phi(\iota_t) - \delta]\, dt + \sigma_k dB_t$$

2. FOC for investment is $q\phi'(\iota^*) = 1$
   - q_t is the price of capital
   - lower nominal rate $\rightarrow$ q_t higher $\rightarrow$ greater investment ι

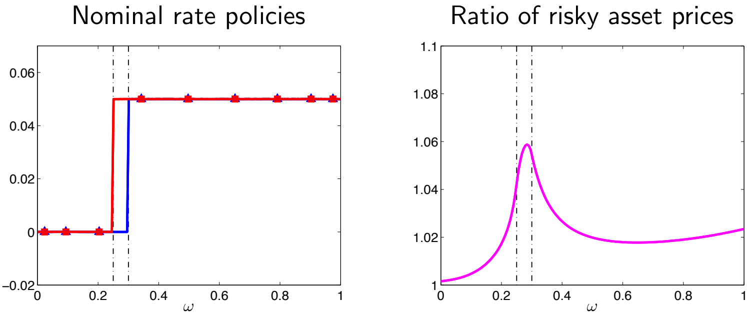
The zero lower bound

1. When $n = 0$, there is no cost to taking leverage so banks are at their unconstrained optimum

2. Because banks cannot be forced to take leverage, the nominal rate cannot go negative by no-arbitrage
   - willing to hold large excess reserves as this is costless

3. Central bank can still raise asset prices by lowering *expected future* nominal rates (forward guidance)

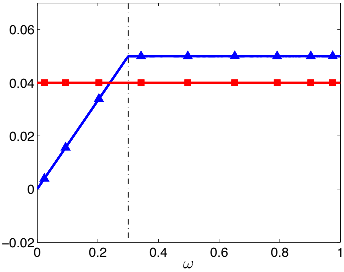
Forward guidance



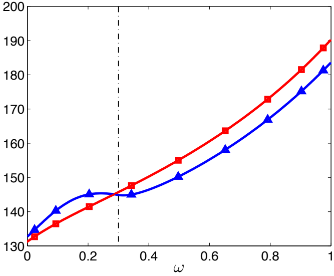
1. Forward guidance delays nominal rate hike from $\omega = 0.25$ to $\omega = 0.3$
2. Prices are higher under forward guidance even for $\omega \ll 0.25$

"Greenspan put"

Nominal rate policies



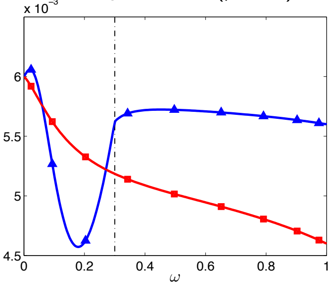
Wealth-consumption ratio (P/D)



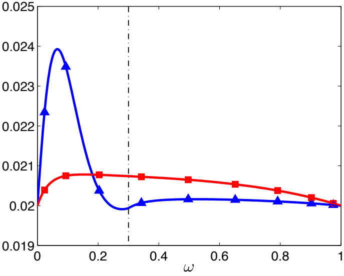
1. Rates lowered in response to large negative shocks ($\omega \leq 0.3$)
   - rates increased when ω is high to have same unconditional mean
2. Near $\omega = 0.3$ valuations are flat in ω because central bank cuts rates in response to negative shocks (as though investors own a put)
   - but prices propped up by increasing leverage so further shocks cause valuations to fall more quickly

"Greenspan put"

Risk premium ($\mu - r$)



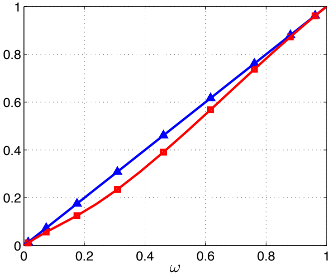
Volatility (σ)



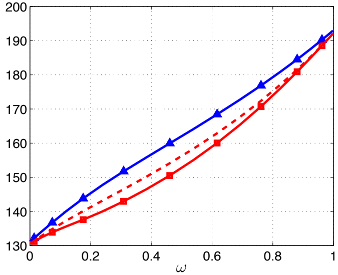
1. Reduces risk premia near $\omega = 0.3$
2. Volatility decreases for ω close to 0.3 due to policy
3. However, if ω declines further then volatility rises sharply because leverage has significantly increased

Policy Shocks

Post-shock wealth share (ω)



Wealth-consumption ratio (P/D)



1. Extend the model to incorporate unexpected shocks (a second state variable)
2. Unexpected nominal rate increase causes ω to decrease
3. Total impact on valuations (red solid line) exceeds direct impact (dashed line) due to negative impact on ω (balance sheet effect)

Takeaway

1. Contemporary monetary policy targets risk premia, not just interest rates
2. An asset pricing framework for studying the relationship between monetary policy and risk premia
3. Monetary policy $\Rightarrow$ external finance spread $\Rightarrow$ leverage $\Rightarrow$ risk premia
4. Dynamic applications: forward guidance, "Greenspan put"

Appendix

Liabilities-side tradeoff

1. Deposits pay a "low" rate due to household liquidity demand
2. But must be backed with greater collateral than non-deposit funding

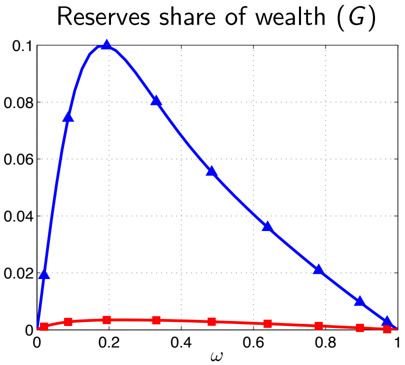
⇒ there is a tradeoff between deposit-taking and leverage
  - similar to tradeoff in Hanson, Shleifer, Stein, and Vishny (2014)

3. Nominal rate controls the spread earned on deposits
  - deposit rates are "sticky", do not move one-to-one with the nominal rate (Driscoll and Judson 2013)

⇒ Nominal rate governs the funding cost vs. leverage tradeoff
  - banks' FOC is the same as in the main model
  - higher nominal rate implies higher cost of taking leverage

BACK

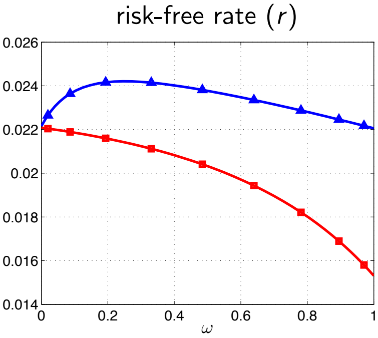
Reserves



$\mathbf{n_1 = 0\%}$
$\mathbf{n_2 = 5\%}$

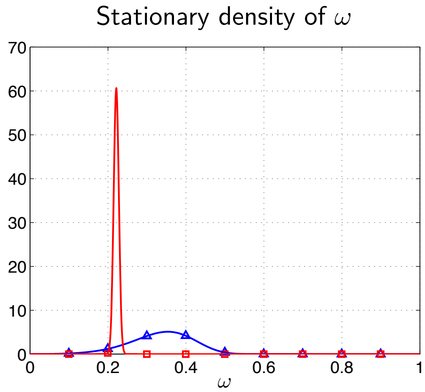
1. Wealth share of reserves is very small at high nominal rates
2. Increases at low nominal rates
   - at zero nominal rate there is no cost to holding reserves

Real interest rate



1. Real rate is lower under the higher nominal rate policy
2. Increase in aggregate risk aversion increases precautionary savings motive (as in a homogeneous economy)
   - i.e., depositors' precautionary motive increases with their risky asset weight
   - can be reversed under depositor liquidity preference (liabilities-side version) or with nominal price rigidities

Wealth distribution



1. For stationarity: introduce births/deaths
   - Wealth is distributed evenly to newly born
2. Lowering nominal rate increases the mean, variance, and left tail of bank wealth share, due to greater risk taking

Transmission of monetary policy

Bernanke and Blinder (AER 1992)

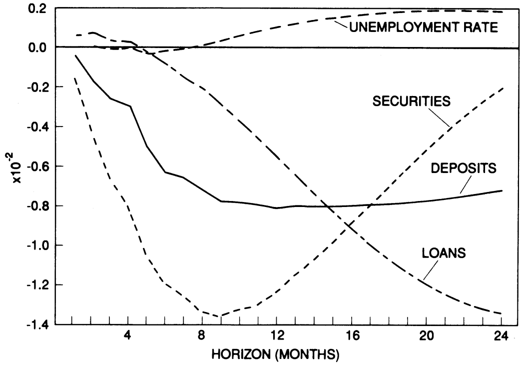


FIGURE 4. RESPONSES TO A SHOCK TO THE FUNDS RATE

1. An increase in the nominal rate is followed by reduction in bank balance sheets/leverage