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
   - silent on *risk premia*

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", Quantitative Easing
   - concerns about financial stability

$\Rightarrow$ We build a dynamic equilibrium asset pricing model of how monetary policy affects risk taking and risk premia

Model overview

1. Central bank sets nominal rate to influence financial sector's cost of leverage and thereby economy's aggregate risk aversion

2. Endowment economy, 2 agent types
   - low risk aversion: pool wealth as equity of financial sector ("banks")
   - high risk aversion: "depositors"
   - banks take leverage by issuing risk-free deposits

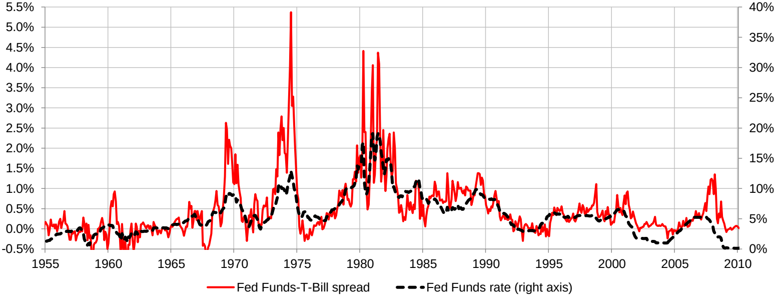
3. Taking deposits exposes banks to funding shocks in which a fraction of deposits are pulled $\rightarrow$ must reduce assets
   - liquidating risky assets rapidly is costly (fire sales)

   $\Rightarrow$ to insure against this banks hold a buffer of liquid assets

4. Central bank regulates the liquidity premium via nominal rate
   - nominal rate = cost of holding reserves (most liquid asset)
   - nominal rate $\propto$ liquidity premia on other liquid assets (govt bonds)
   - lower nominal rate $\rightarrow$ liquidity buffer less costly to hold
     - $\rightarrow$ taking leverage is cheaper
     - $\rightarrow$ bank risk taking rises
     - $\rightarrow$ risk premia and cost of capital fall

Nominal rate and the liquidity premium

1. Graph plots FF-Tbill spread (Tbill liquidity premium) against FF rate
   - liquidity premium co-moves strongly with nominal rate
   - see also results in Nagel (2014)
2. Banks hold large liquid security buffers ($\approx$ 30%) against short-term debt ($\approx$ 75% of all liabilities)
   - similarly, broker-dealers, SPVs, hedge funds, open-end mutual funds



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); Landier, Sraer, and Thesmar (2013); Hanson and Stein (2014); Sunderam (2013); Nagel (2014); Drechsler, Savov, and Schnabl (2015b)
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: $dY_t/Y_t = \mu_Y dt + \sigma_Y dB_t$
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 A agents (banks) share of wealth:

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

Financial assets

1. Risky asset is a claim to Y_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. Deposits subject to funding shocks $\rightarrow$ fraction of deposits are pulled
   - rapidly liquidating risky assets is costly (fire sales)

$\Rightarrow$ Banks want to fully self insure by holding liquid assets in proportion to deposits/leverage

- $w_{S,t}$ = risky asset portfolio share
- $w_{L,t}$ = liquid assets portfolio share

$$\begin{aligned} w_{L,t} &\geq \max\left[\lambda\left(w_{S,t}-1\right),0\right] \\ w_{L,t} &= \underbrace{w_{G,t}}_{\text{Govt./Agency bonds}} + \underbrace{m}_{>1} \times \underbrace{w_{M,t}}_{\text{Reserves}} \end{aligned}$$

Inflation and the nominal rate

1. Each \$ of reserves is worth π_t consumption units. We take reserves as the numeraire, so π_t is the inverse price level.

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

   - For simplicity, we restrict attention to nominal rate policies under which $d\pi/\pi$ is locally deterministic

2. Define the nominal rate

$$n_t = r_t + i_t$$

   - n_t = nominal deposit rate in the model = Fed funds rate
   - $n_t = n(\omega_t)$ is the central bank's policy rule, which agents know

Liquidity premium

1. Reserves' liquidity premium equals opportunity cost of holding them

$$r_t - \frac{d\pi_t}{\pi_t} = r_t + i = n_t$$

2. Government bonds pay a real interest rate r_t^g. Their liquidity premium is

$$r_t - r_t^g = \frac{1}{m} n_t$$

   - In data: 78% correlation of FF and FF-Tbill spread

3. Since government liabilities earn a liquidity premium, they generate seigniorage profits at the rate

$$\Pi_t \frac{n_t}{m}$$

   where Π_t is the liquidity value of government liabilities
   - govt refunds seigniorage in proportion to agents' wealth

Optimization

1. HJB equation for each agent type is:

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

subject to

$$\begin{aligned} w_L &= \max\left[\lambda\left(w_S - 1\right), 0\right] \\ \frac{dW}{W} &= \left[r - c + w_S\left(\mu - r\right) - w_L \frac{n}{m} + \Pi \frac{n}{m}\right] dt + w_S \sigma dB \end{aligned}$$

- n/m is the liquidity premium of government bonds
- $\Pi \frac{n}{m}$ is seignorage payments

Optimality conditions

1. Each agent's value function has the form

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

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

3. If $\frac{\lambda}{m} n < (\gamma^B - \gamma^A)\sigma_Y^2$, the portfolio FOCs give $w_S^A > 1$ with

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

$\Rightarrow$ raising n raises the cost of taking leverage
$\Rightarrow$ reduces risk taking w_S^A
$\Rightarrow$ increases risk premia (effective aggregate risk aversion)

How does the central bank change the nominal rate?

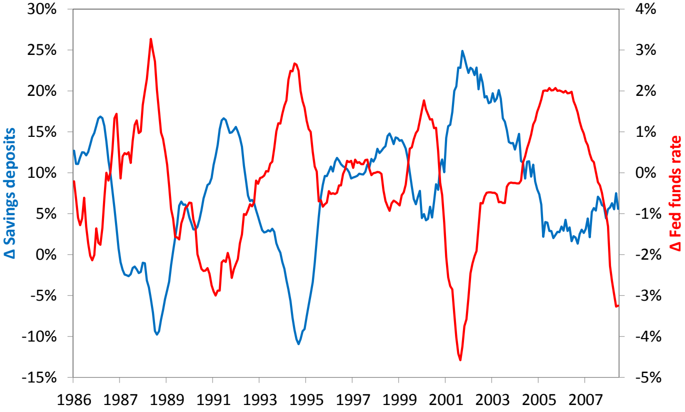
1. The supply of liquidity must evolve consistent with the liquidity demand that obtains under the chosen policy $n_t = n(\omega_t)$.
   - given in Proposition 3 in the paper

$\Rightarrow$ Implementing rate increase (liquidity demanded $\downarrow$) requires a contraction in reserves or liquid bonds

2. In practice, retail bank deposits are a major source of household liquidity ($8 trillion)
   - DSS (2015b) show that when n_t increases, banks reduce the supply of retail deposits and raise their price/liquidity premium
   - DSS (2015b) show this is due to banks' market power over retail deposits

Retail deposit supply and the nominal rate (DSS 2015b)

- When the nominal rate rises, banks increase the interest spread charged on retail deposits and decrease deposit supply



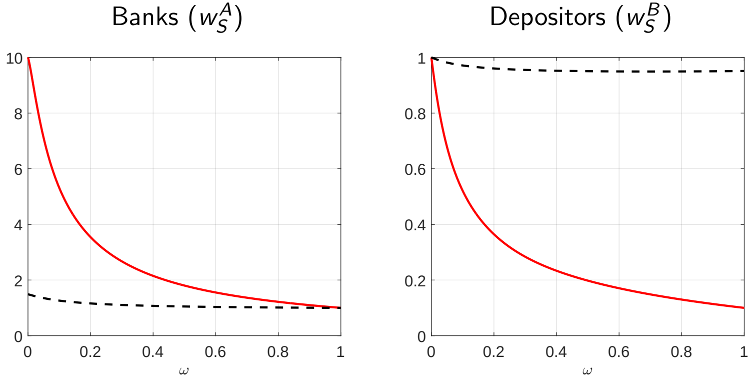
⇒ When the nominal rate increases, private liquidity supply contracts

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
Endowment growth	μ_Y	0.02
Endowment volatility	σ_Y	0.02
Time preference	ρ	0.01
Funding shock size	$\lambda/(1+\lambda)$	0.29
Govt. bond liquidity	$1/m$	0.25
Nominal rate 1	n_1	0%
Nominal rate 2	n_2	5%

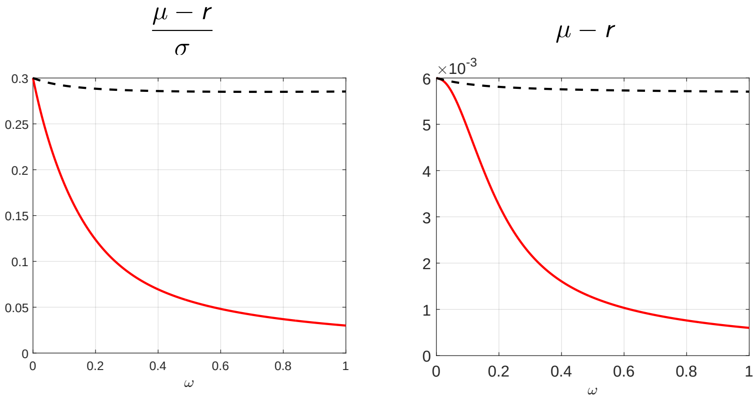
Risk taking



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

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

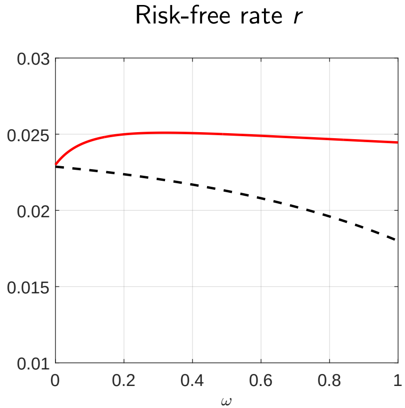


$\mathbf{n_1 = 0\%}$

$\mathbf{n_2 = 5\%}$

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

Real interest rate

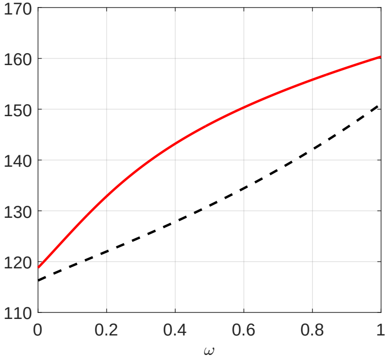


$\mathbf{n_1 = 0\%}$
$\mathbf{n_2 = 5\%}$

1. Real rate is lower under the higher nominal rate policy
2. Reduction in risk sharing increases precautionary savings
   - increase in effective risk aversion lowers the real rate (as in homogenous economy)

Valuations/cost of capital

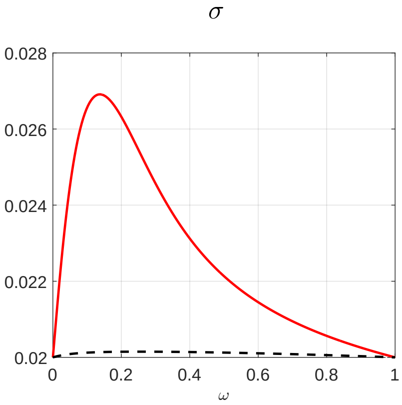
Price-dividend ratio P/Y



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

1. Lower rates increase valuations for all ω
   - effect is largest for moderate ω, where aggregate risk sharing/leverage is at its peak

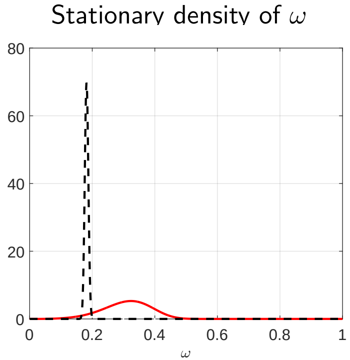
Volatility



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

1. There is greater excess volatility at lower nominal rates
   - ω more volatile since leverage is higher
   - and risk premium more sensitive to ω

Wealth distribution



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

1. For stationarity: introduce births/deaths
   - agents die at rate κ and are born as (A, B) with fraction $(\overline{\omega}, 1 - \overline{\omega})$
   - wealth is distributed evenly to newly born
2. Lower nominal rate $\rightarrow$ greater mean, variance, and left tail of ω distribution, due to greater bank risk taking

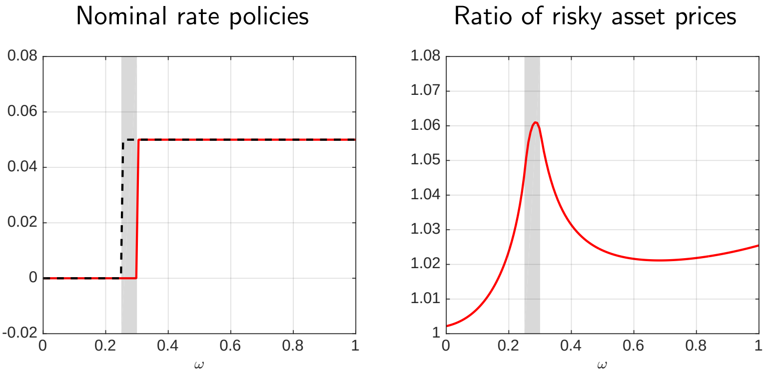
Applications: the zero lower bound

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

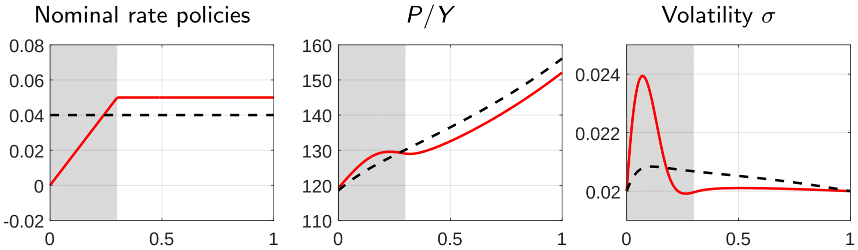
3. Central bank can raise asset prices further by lowering *expected future* nominal rates (forward guidance)

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 $\omega \ll 0.25$
3. Prices most sensitive to policy timing near liftoff ("taper tantrum")

"Greenspan put"



1. Rates lowered in response to large negative shocks ($\omega \leq 0.3$)
2. Near $\omega = 0.3$ valuations are flat in ω as central bank cuts rates in response to negative shocks (as though investors own a put)
3. But heightened leverage $\rightarrow$ further shocks cause prices to fall quickly
4. Volatility low for ω close to 0.3 but rises sharply for lower ω

Nominal rate shocks and economic activity

1. Introduce unexpected/independent shocks to nominal rate n_t

$$dn_t = -\kappa_n \left[n_t - n_0\left(\omega_t\right)\right] dt + \sigma_n \sqrt{\left(n_t - \underline{n}\right)\left(\overline{n} - n_t\right)} dB_t^n$$

   - push n_t away from the known benchmark rule $n_0\left(\omega_t\right)$
   - n_t now a second state variable (in addition to ω_t)

2. To study effects on output, add production: capital k_t, investment ι_t

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

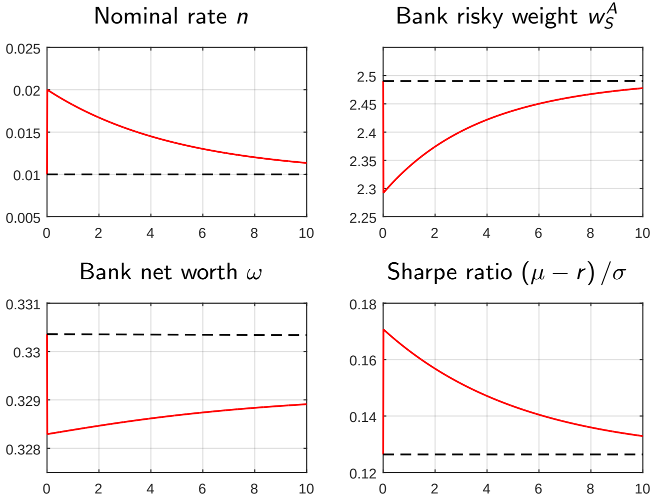
   - investment subject to convex adj. cost: $\phi'' < 0$
   - output from capital $Y_t = ak_t$
   - price of one unit of capital: $q_t = q\left(\omega_t, n_t\right)$
   - optimal investment (q-theory): $q_t \phi'\left(\iota_t\right) = 1$

3. Make real rate invariant to nominal shocks by incorporating a transitory component in total output (an output gap, e.g., labor)
   - otherwise output is rigid in the short run

   $\Rightarrow$ nominal shocks affect capital price q only through risk premium

4. Parameters consistent with data/literature

Impulse responses: financial markets

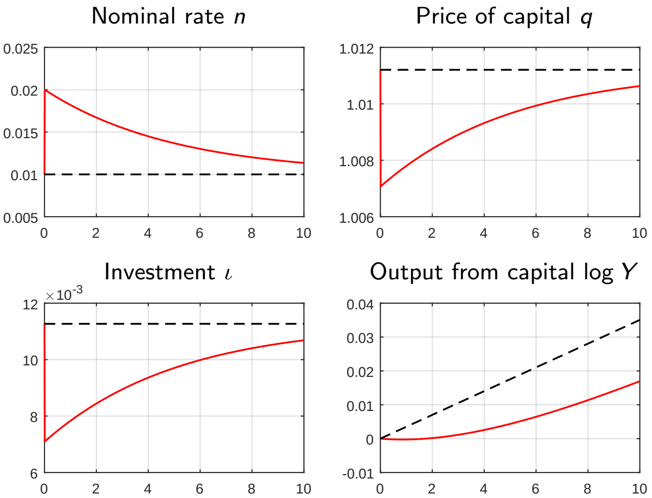


- Persistent drop in bank risk taking/leverage

$\Rightarrow$ Long-lived drop in bank net worth; "financial accelerator"

$\Rightarrow$ Persistent rise in Sharpe ratio

Impulse responses: economic activity

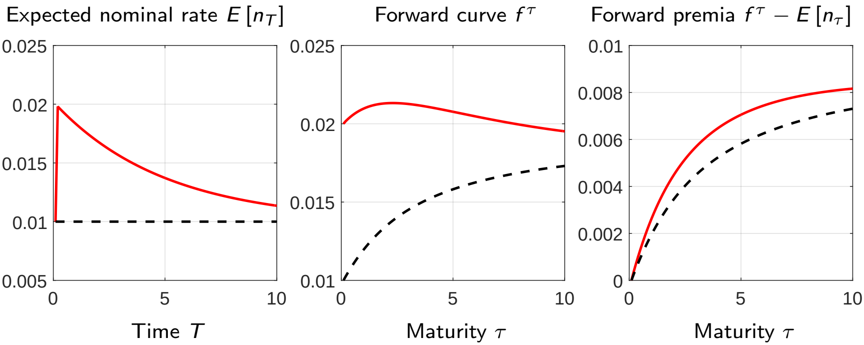


- Increase in risk premia $\Rightarrow$ drop in the price of capital

$\Rightarrow$ Investment falls (initially even below depreciation rate)

$\Rightarrow$ Output growth stalls, level is permanently lower in the long run

The nominal yield curve



1. Curve slopes up even in steady state (when $E[n_T]$ is flat)
   - $\Rightarrow$ model generates substantial term premium
     - because high nominal rates $\rightarrow$ low risk sharing/high marginal utility
2. Forward term premia increase substantially with positive rate shocks
   - $\approx$ 10 bps at long end
   - consistent with finding of Hanson and Stein (2014)

Takeaways

1. Monetary policy affects/targets risk premia, not just interest rates
2. An asset pricing framework for studying the effect of monetary policy on risk premia
3. Monetary policy $\Rightarrow$ liquidity premium $\Rightarrow$ risk taking/leverage $\Rightarrow$ risk premia
4. Dynamic applications: forward guidance, "Greenspan put," economic activity, the yield curve