Why Does the Fed Move Markets so Much? A Model of Monetary Policy and Time-Varying Risk Aversion[1]

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[1] *Github code repository*, *Published version of paper*

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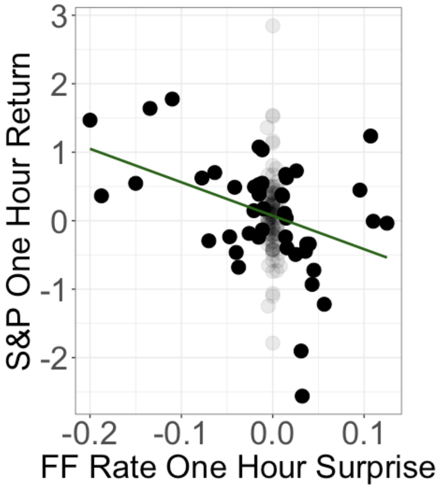
- **This paper:**
  1. Newly integrate finance habits of Campbell, Pflueger, and Viceira (2020) with baseline New Keynesian model of monetary policy
  2. Large stock market responses to monetary policy announcement and equity volatility puzzle (Shiller (1981)) two sides of same coin

Stocks Respond to Federal Funds Rate on FOMC Dates

Bernanke and Kuttner (2005)



Response to economic news? Risk premia? Over-reaction?

Results Preview: Stocks on FOMC Dates

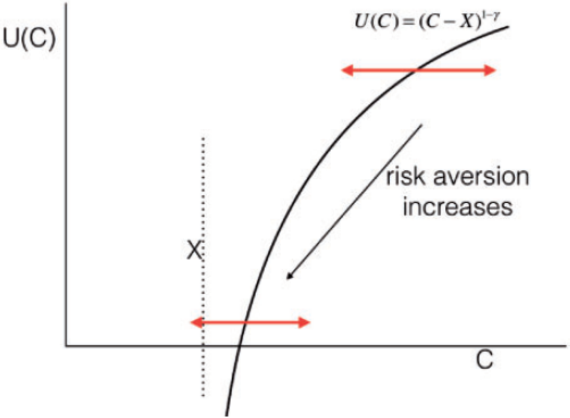
- Model fit to quarterly data naturally explains large stock responses on FOMC dates
- Higher short rate depresses consumption and willingness to take risk, thereby leading to persistent effect on risk premia
- Time-varying risk premia explain 80% of stock response, in line with Bernanke and Kuttner (2005) and Bauer, Bernanke, and Milstein (2023)'s findings
- Monetary policy moves risk premia in line with how much it moves economy

Related Literature

- **Bonds and Stocks on FOMC Dates:** Bernanke and Kuttner (2005), Cochrane and Piazzesi (2002), Hanson and Stein (2015), Nakamura and Steinsson (2018), Drechsler, Savov, and Schnabl (2018), Jarociński, and Karadi (2020), Kekre and Lenel (2020), Lagos and Zhang (2020), Bianchi, Lettau and Ludvigson (2020), Bianchi, Ludvigson and Ma (2023).
- **Habits and Asset Prices:** Constantinides (1990), Campbell and Cochrane (1999), Bekaert, Engstrom and Grenadier (2010), Bekaert and Engstrom (2017), Bekaert, Engstrom and Xu (2019), Campbell, Pflueger, and Viceira (2020)
- **Habits and Macro:** Lettau and Uhlig (2000), Fuhrer (2000), Boldrin, Christiano, and Fisher (2001), Christiano, Eichenbaum and Evans (2005)
- **Asset Pricing in New Keynesian Models:** Uhlig (2007), Rudebusch and Swanson (2008, 2012, 2019), Dew-Becker (2014), Kung (2015), Swanson (2021), Caballero and Simsek (2023), Gourio and Ng (2020, 2023)

Our contribution: Same preferences that explain equity volatility puzzle also explain large stock response to monetary policy

Countercylical Risk Aversion



Cochrane (2017), Figure 1

New: Output and consumption endogenous to policy

Modeling Habit via Surplus Consumption

$$
\begin{aligned}
s_{t+1} &= (1-\theta_0)\bar{s} + \theta_0 s_t + \theta_1 x_t + \theta_2 x_{t-1} + \lambda(s_t)\varepsilon_{c,t+1}, \\
\varepsilon_{c,t+1} &= c_{t+1} - E_t c_{t+1}
\end{aligned}
$$

s_t= log surplus consumption, c_t= log consumption,

- Output gap x_t equals stochastically de-trended consumption (up to constant)

$$x_t = c_t - (1-\phi)\sum_{j=0}^{\infty}\phi^j c_{t-1-j}$$

- Implied habit ≈ distributed lag of consumption and consumption relative to frictionless baseline
- Non-linear $\lambda(s_t)$ decreases in s_t (Campbell and Cochrane, 1999)
    - Business cycle variation in risk premia (Fama and French, 1989)
- $\theta_1 < 0$ and $\theta_2 > 0$ (Campbell, Pflueger, and Viceira, 2020) increases

Macro Euler Equation from Pricing Risk-Free Rate

$$1 = E_t \left[M_{t+1} exp(r_t) \right]$$

Stochastic discount factor (SDF) $M_{t+1} = \beta exp\left(-\gamma(\Delta c_{t+1} + \Delta s_{t+1})\right)$ gives (up to constant):

$$\begin{aligned} r_t &= \gamma \mathrm{E}_t \Delta c_{t+1} + \gamma \mathrm{E}_t \Delta s_{t+1} - \frac{\gamma^2}{2}\left(1+\lambda(s_t)\right)^2 \sigma_c^2, \\ &= \gamma \mathrm{E}_t \Delta c_{t+1} + \gamma \theta_1 x_t + \gamma \theta_2 x_{t-1} \\ &\quad \underbrace{+\gamma(\theta_0 - 1)s_t - \frac{\gamma^2}{2}\left(1+\lambda(s_t)\right)^2 \sigma_c^2}_{=0}. \end{aligned}$$

- Rearranging gives exactly log-linear consumption **Euler equation**:

$$x_t = \underbrace{f^x}_{\frac{1}{\phi-\theta_1}} E_t x_{t+1} + \underbrace{\rho^x}_{\frac{\theta_2}{\phi-\theta_1}} x_{t-1} - \underbrace{\psi}_{\frac{1}{\gamma(\phi-\theta_1)}} r_t$$

- Habits give forward- and backward-looking Euler equation

Phillips Curve

- Supply side summarized by standard log-linearized **Phillips curve** (Calvo (1983))

$$\pi_t = f^\pi E_t \pi_{t+1} + \rho^\pi \pi_{t-1} + \kappa x_t$$

  constants ρ^π, f^π, κ

- "Hot economy" x_t generates price-pressure
- No real investment, so consumption equals output $C_t = Y_t$

Monetary Policy Rule

- Inertial Taylor-type **monetary policy rule** for nominal interest rate i_t

$$i_t = \rho^i i_{t-1} + (1-\rho^i)(\gamma^\pi \pi_t + \gamma^x x_t) + v_t$$

- γ^x and γ^π are long-term output gap and inflation weights
- ρ^i is inertia parameter, determines how quickly monetary policy adjusts towards the target rate
- v_t: Monetary policy shock
- Model high-frequency announcement return by assuming that MP shock consists of independent FOMC and pre-FOMC components

$$v_t = v_t^{pre} + v_t^{FOMC}$$

SOLUTION

Summary: Macroeconomic Equilibrium

- Euler equation:

$$x_t = \frac{1}{\phi - \theta_1}\mathrm{E}_t x_{t+1} + \frac{\theta_2}{\phi - \theta_1} x_{t-1} - \frac{1}{\gamma(\phi - \theta_1)} r_t$$

- Phillips curve:

$$\pi_t = f^{\pi} E_t \pi_{t+1} + \rho^{\pi} \pi_{t-1} + \kappa x_t$$

- Monetary policy rule:

$$i_t = \rho^i i_{t-1} + (1 - \rho^i)\left(\gamma^x x_t + \gamma^{\pi} \pi_t\right) + v_t$$

- Fisher equation for one-period bond: $i_t = r_t + E_t \pi_{t+1}$
- Homoskedastic iid fundamental shock: v_t

Solution

- Solve for macroeconomic dynamics of form

$$Y_t = BY_{t-1} + \Sigma v_t,$$

where

$$Y_t = [x_t, \pi_t, i_t]'$$

- Consumption innovation $\varepsilon_{c,t}$ is log-normal, homoskedastic as previously conjectured

- Preserve full non-linearity of asset prices by solving value function iteration numerically on four-dimensional grid

- Additional asset price state variable s_t is highly nonlinear, but driven by same shock

Asset Pricing Recursions

- Recursion for n-period zero coupon nominal bond

$$P^{\$}_{n,t} \quad = \quad \mathrm{E}_t \left[M_{t+1} \exp(-\pi_{t+1}) P^{\$}_{n-1,t+1} \right]$$

- Stocks are levered claim on consumption (Abel (1990))
- Recursion for n-period zero coupon consumption claim

$$\frac{P^c_{nt}}{C_t} = \mathrm{E}_t \left[M_{t+1} \frac{C_{t+1}}{C_t} \frac{P^c_{n-1,t+1}}{C_{t+1}} \right]$$

- Illustrative analytic risk premium on one-period zero coupon consumption claim

$$E_t \left[r^c_{1,t+1} - r_t \right] + \frac{1}{2} Var \left(r^c_{1,t+1} \right) \quad = \quad \gamma (1 + \lambda (s_t)) \sigma^2_c.$$

Surplus consumption ↓ stock risk premium ↑

CALIBRATION

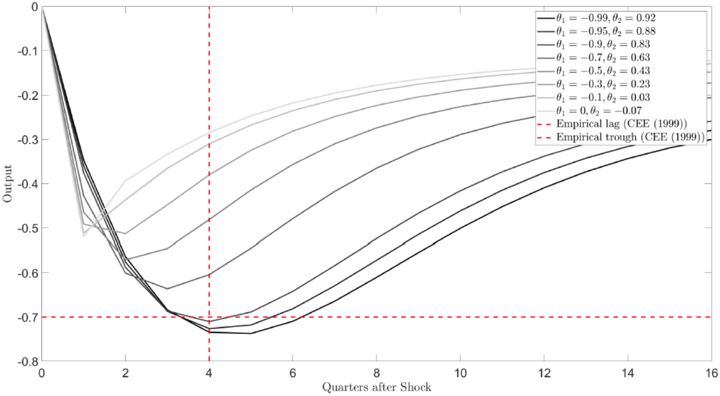
Model Calibrated to Quarterly Macro Impulse Responses

- **Step 1:** Calibrate preference, firm and monetary policy parameters to standard values

- **Step 2:**
  - Set habit parameter θ_1 and θ_2 to match hump-shaped output response to monetary policy shock in data (Christiano, Eichenbaum, Evans (2005))
  - θ_2 set to ensure that coefficients in Euler equation add up to one
  - σ_{MP} set to target quarterly consumption volatility of 1.50%
  - $\sigma_{MP}^{FOMC} = 6.52$bps matches volatility of fed funds futures in 30 minute intervals around FOMC announcements

Consumption Response by Habit Parameter

Fig. 2 Model Output Response for Different Habit Parameters



Habit important to match consumption response to MP shock.

Quarterly Asset Prices

Table 3 Unconditional Quarterly Model Properties

Stocks		Model	Data
	Equity Premium	7.29	7.84
	Volatility	14.87	16.87
	Sharpe Ratio	0.49	0.47
	AR(1) Coeff. pd	0.93	0.92
	1-YR Excess Returns on pd	-0.34	-0.38
	1-YR Excess Returns on pd (R^2)	0.07	0.23
10-Year Nominal Bonds			
	Yield Spread	0.94	1.87
	Volatility Excess Returns	2.57	9.35
	1-YR Excess Returns on Yield Spread	-0.18	2.69
	1-YR Excess Returns on Yield Spread (R^2)	0.01	0.14
Macroeconomic Dynamics			
	Std. Annual Cons. Growth	1.55	1.50
	Std. Annual Change fed funds Rate	2.13	1.35
	Trough Output Response to 100 bps fed funds Surprise	-0.71	-0.7
	Lag Trough Output Response	4 Quarters	4-6 Quarters

Plausible consumption vol, and consumption response to monetary policy, volatile and predictable stock returns

FOMC DATE RETURNS

Bernanke-Kuttner Regressions Model vs. Data

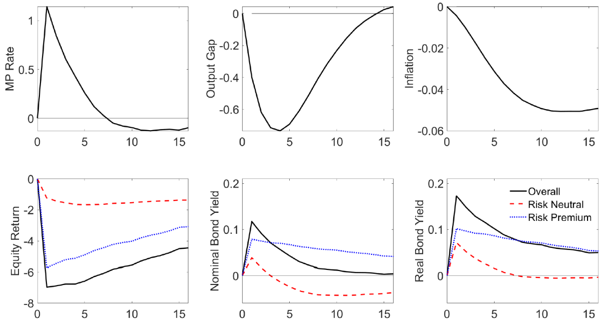
Table 4 Stock Market onto High-Frequency Monetary Policy Shocks

	Data			Model					
				Overall		Risk Neutral		Risk Premium	
FF Shock	-3.02***	-2.73*	-6.14***	-6.37	-6.31	-1.23	-1.22	-5.13	-5.08
	(0.99)	(1.53)	(1.16)						
FF Shock × (FF Shock>0)		0.54			-0.07		-0.02		-0.06
		(2.14)							
Timing			-5.67***						
			(1.52)						

Model matches large stock response to MP shocks, endogenously time-varying risk premia important

Asset Price Impulse Responses

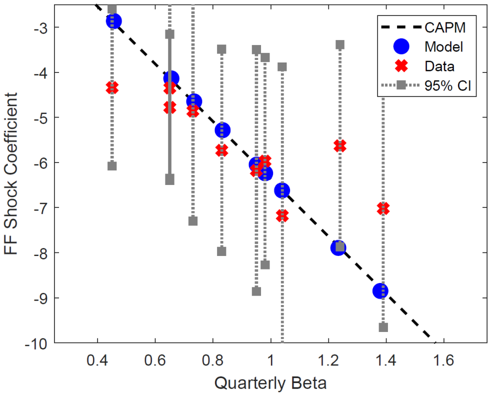
Fig. 3 Model Impulse Responses to Monetary Policy Shock



MP hike is bad news for surplus consumption ⇒ stock market falls more than discounted expected present value of dividends

Cross-Sectional Implications

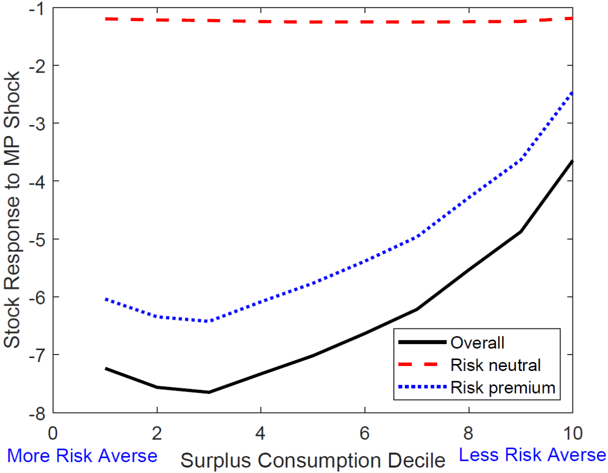
Fig. 4 Industry Returns onto High-Frequency Monetary Policy Shocks



Bernanke and Kuttner (2005) showed that high-beta industries respond more to MP shocks. Model matches this, as high-beta stocks have higher and more volatile risk premia.

Implications by Risk Aversion

Fig. 5 Model Stock Returns onto High-Frequency Monetary Policy Shock by Risk Aversion



Implications by Risk Aversion

Table 6 Stock Returns onto High-Frequency Monetary Policy Shocks by Risk Aversion

	Mkt	Utils	NoDur	Hlth	Enrgy	Shops	Telcm	Manuf	Other	Durbl	HiTec
Data - High-Frequency Regression											
FF Shock	-4.14***	-4.33***	-3.79***	-2.94**	-3.26***	-4.30***	-4.78***	-3.99***	-4.43***	-3.97***	-4.65***
	(1.14)	(0.76)	(0.92)	(1.21)	(1.04)	(1.17)	(1.23)	(1.08)	(1.48)	(1.18)	(1.36)
FF Shock (RA_t >Med)	-3.25**	-0.18	-1.68	-2.26	-2.74*	-2.43*	-2.37	-3.15**	-4.38**	-2.74*	-3.86**
	(1.57)	(1.17)	(1.14)	(1.51)	(1.51)	(1.46)	(1.52)	(1.43)	(2.15)	(1.43)	(1.88)
Model - High-Frequency Regression											
FF Shock	-5.39	-2.43	-3.50	-3.5	-3.94	-4.47	-5.12	-5.28	-5.61	-6.69	-7.49
FF Shock (RA_t >Med)	-1.97	-0.89	-1.28	-1.28	-1.44	-1.64	-1.87	-1.93	-2.05	-2.44	-2.74
Empirical Quarterly Beta											
	1	0.45	0.65	0.65	0.73	0.83	0.95	0.98	1.04	1.24	1.39
	(0.00)	(0.08)	(0.06)	(0.06)	(0.09)	(0.05)	(0.07)	(0.05)	(0.05)	(0.09)	(0.07)

More negative stock response to MP surprises when risk aversion is high, both in model and in data.

Implications for Bond Yields

Table 7 10-Year Bond Yields onto High-Frequency Monetary Policy Shocks

	Surprise: Fed Funds			*Surprise: 3M Fed Funds Futures*			*Surprise: Nakamura-Steinsson*		
Data	Nominal	Real	Bkeven	Nominal	Real	Bkeven	Nominal	Real	Bkeven
	0.04	0.26*	-0.14	0.25*	0.39**	-0.09	0.68***	0.74***	-0.11
	(0.12)	(0.14)	(0.09)	(0.14)	(0.18)	(0.11)	(0.14)	(0.17)	(0.10)
Model									
Overall	0.11	0.16	-0.05	0.15	0.22	-0.07	0.16	0.24	-0.08
Risk Neutral	0.04	0.07	-0.03	0.05	0.1	-0.05	0.06	0.11	-0.05
Risk Premium	0.07	0.09	-0.02	0.09	0.12	-0.03	0.1	0.13	-0.03

Bond risk premium responses can be sizeable in model, but will depend on bond beta.

Conclusion

- Identified monetary policy shocks are basic building block monetary policy
- Proof-of-concept model linking monetary policy risk premia to standard asset pricing facts
- Model jointly generates high quarterly stock return volatility, risk-free rate dynamics, and large stock responses to monetary policy news
- Successful at explaining broad range of asset price responses to monetary policy surprises on FOMC dates