Financial Vulnerability and Monetary Policy

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What is the Nexus Between Monetary Policy and Financial Vulnerability?

Financial vulnerability: Amplification mechanisms in the financial sector

Two questions are hotly debated

1. Does monetary policy impact the degree of financial vulnerability?
2. Should monetary policy take financial vulnerability into account?

Traditional View:
Financial Vulnerability not Crucial for Monetary Policy

- Inflation targeting literature largely dismisses relevance of financial stability
  - Bernanke Gertler (1999), Curdia Woodford (2016)

- Cost-benefit analysis argues never to use monetary policy for financial stability
  - Svensson (2014, 2016)

- Monetary policy too blunt an instrument, use macro-prudential tools instead
  - Bernanke (2011), Kohn (2015)

Our Contributions

- Framework that captures joint behavior of inflation, output, and financial vulnerability
  - Realistic and empirically relevant based on GDP-at-Risk
  - Tractable and parsimonious
  - Can be expanded to larger scale DSGEs
- New Keynesian (NK) model with financial vulnerability
  - Intermediation sector with frictions: Value-at-Risk (VaR) constraint
  - VaR constraint creates vulnerability through asset prices
- NKV

Preview of Conclusions

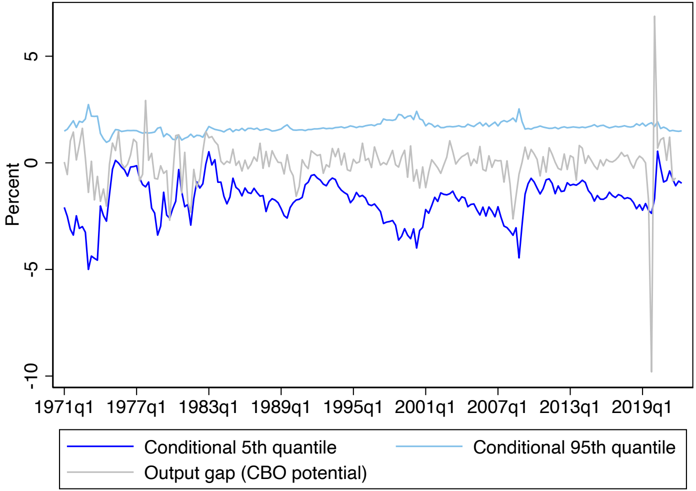
1. Monetary policy should always take financial vulnerability into account

2. Quantitatively large tradeoff between financial vulnerability and dual mandate
   - Through the risk taking channel of monetary policy

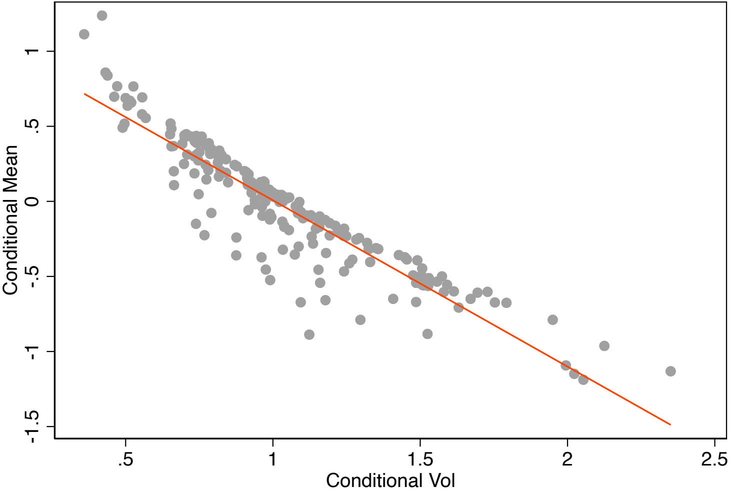
3. Optimal policy can be implemented with flexible inflation targeting

Financial Variables Predict Tail of Output Gap Distribution

Based on "Vulnerable Growth" by Adrian, Boyarchenko and Giannone (AER, 2018)

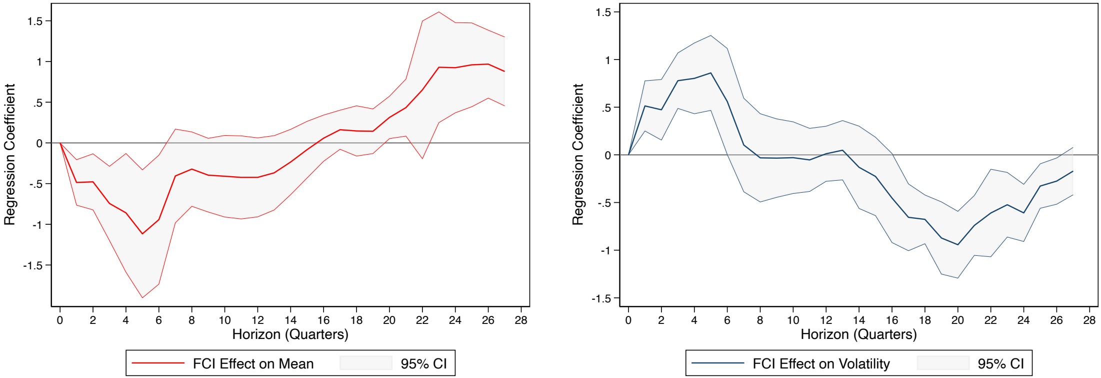


High-Mean Low-Vol for Conditional Output Gap Growth



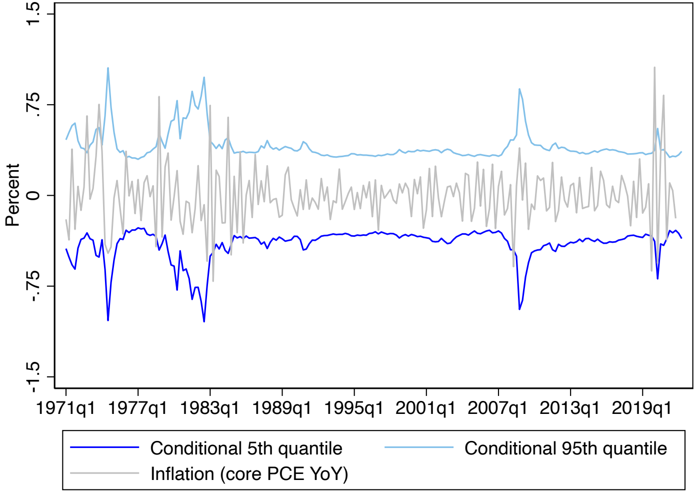
Cond Mean = 1.12 - 1.11 x Cond Vol + ε

Output Gap Local Projections Show Intertemporal Tradeoff

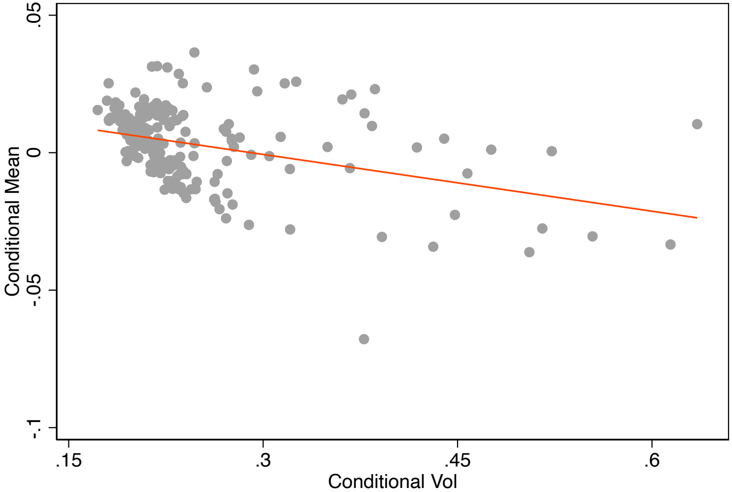


- Conditioning on financial conditions reveals “Volatility Paradox”
- IRF from LP equivalent to VAR, Plagborg-Møller and Wolf (Econometrica, 2021)

Conditional Inflation Quantiles Are Symmetric

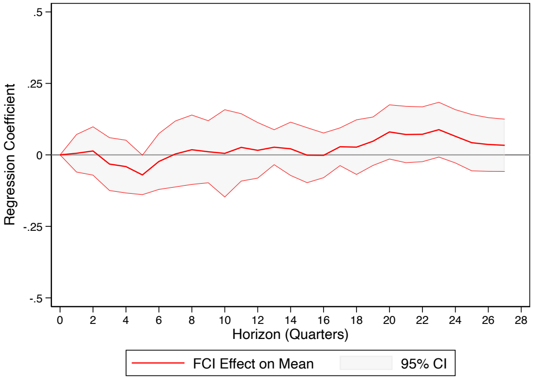


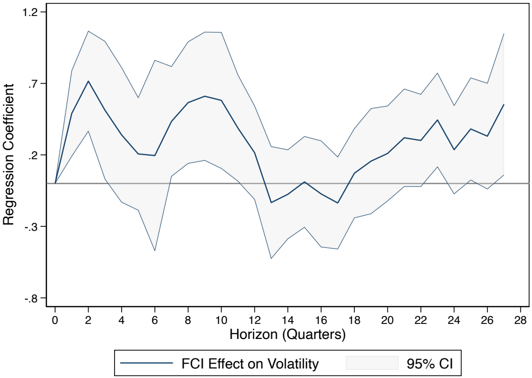
No Conditional Mean-Vol Correlation for Inflation



Cond Mean = 0.02 - 0.07 x Cond Vol + ε

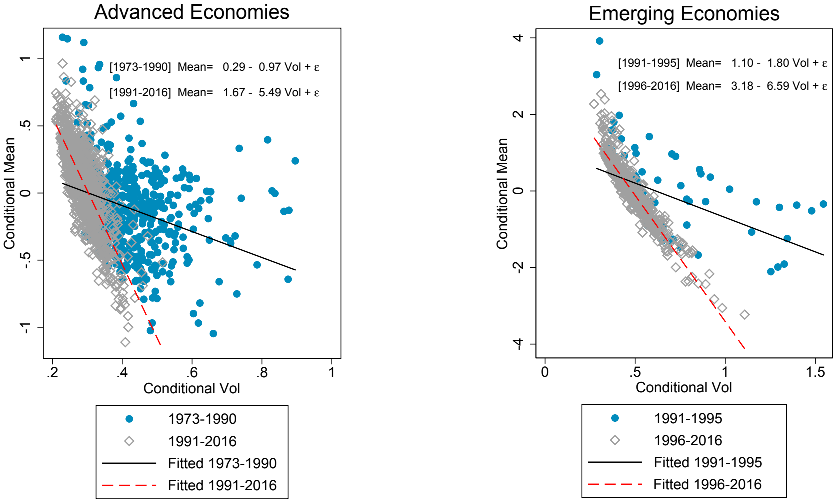
Inflation Local Projections Give No Volatility Paradox





Similar Patterns Hold in Panel of Countries

Based on Adrian, Duarte, Grinberg and Mancini-Griffoli (IMF volume, 2018)



Overview of Microfounded Non-Linear Model

- Firm optimization gives standard New Keynesian Phillips Curve
- Households as in New Keynesian model but
  - Cannot finance firms directly
  - Can trade any financial assets (stocks, riskless desposits, etc.) with banks
- Banks
  - Finance firms
  - Trade financial assets with households and among themselves
  - Have a preference (risk aversion) shock
  - Subject to Value-at-Risk constraint
- **Financial markets are complete but prices are distorted**

Price of Risk and No Arbitrage

- Single source of risk Z_t
- Stochastic discount factor $SDF_{s|t} = Q_s/Q_t$ with

$$dQ_t \equiv -Q_t R_t dt - Q_t \eta_t dZ_t \qquad \text{and} \qquad Q_0 \equiv 1$$

such that for all assets with payoffs D_s the price is

$$Q_t S_t = \mathbb{E}_t \left[\int_t^{\infty} Q_s D_s ds \right]$$

- η_t is the market price of risk
- R_t is real risk-free rate, $i_t = R_t - \pi_t$ is nominal risk-free rate
- With volatility σ_t expected excess returns $\mu_t = \eta_t \sigma_t$

The Intermediation Sector Setup

- "Banks" solve portfolio problem with VaR constraint and preference shocks

$$\max_{\{\theta_t,\delta_t\}} \mathbb{E}_t \left[\int_t^{\infty} e^{-\beta(s-t)} e^{\zeta_s} \log\left(\delta_s X_s\right) ds \right]$$

subject to

Budget constraint: $$\frac{dX_t}{X_t} = \left(i_t - \pi_t - \delta_t + \theta_t \mu_t\right) dt + \theta_t \sigma_t dZ_t$$

Value-at-Risk constraint: $$VaR_{\tau,\alpha}\left(X_t\right) \leq a_V X_t$$

Exogenous processes: $$\begin{cases} d\zeta_t = -\frac{1}{2} s_t^2 dt - s_t dZ_t \\ ds_t = -\kappa(s_t - \bar{s}) + \sigma_s dZ_t \end{cases}$$

The Intermediation Sector Setup

- "Banks" solve portfolio problem with VaR constraint and preference shocks

$$\max_{\{\theta_t,\delta_t\}} \mathbb{E}_t^{bank}\left[\int_t^{\infty} e^{-\beta(s-t)}\log\left(\delta_s X_s\right) ds\right]$$

subject to

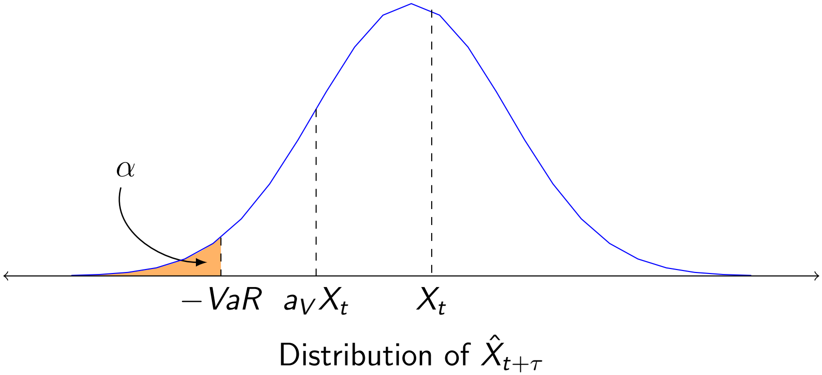
$$\text{Budget constraint:} \quad \frac{dX_t}{X_t} = \left(i_t - \pi_t - \delta_t + \theta_t\mu_t - \theta_t\sigma_t s_t\right) dt + \theta_t\sigma_t dZ_t^{bank}$$

$$\text{Value-at-Risk constraint:} \quad VaR_{\tau,\alpha}^{bank}\left(X_t\right) \leq a_V X_t$$

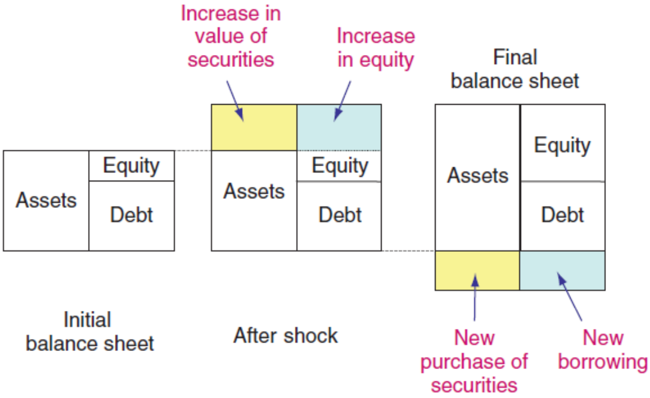
$$\text{Exogenous process:} \quad ds_t = -\kappa(s_t - \bar{s}) + \sigma_s dZ_t^{bank}$$

The VaR Constraint Limits Tail Risk

- Let $\hat{X}_t$ be projected wealth with fixed portfolio weights from t to $t+\tau$
- $VaR_{\tau,\alpha}(X_t)$ is the negative of the α^{th} quantile of the distribution of $\hat{X}_{t+\tau}$ conditional on time-t information



The VaR Constraint Creates Vulnerability



Optimal Portfolio and Dividends

Portfolio of risky assets (leverage): $\theta_t = \frac{1}{\gamma_t}(\mu_t/\sigma_t^2 - s_t/\sigma_t)$

Dividend distribution: $\delta_t = u\left(\gamma_t, \eta_t - s_t\right)\beta$

$$\gamma_t \in (1, \infty) \text{ such that VaR binds with equality}$$

$$\text{or } \gamma_t = 1 \text{ if VaR constraint does not bind}$$

- Changes in “effective risk aversion” γ_t amplify leverage response
- Lower δ_t when γ_t, λ_t, η_t are higher

Stochastic Discount Factor of Intermediaries

- Lagrange multiplier of VaR increasing in η_t and γ_t

$$\lambda_{VaR,t} = \frac{1}{\beta\tau}\left(\frac{1}{u(\gamma_t, \eta_t - s_t)} - 1\right)$$

- Marginal value of one unit of wealth is

$$Q_t^{bank} = \frac{e^{-\beta t} e^{\zeta_t}}{\beta X_t}(1 + 2\beta\tau\lambda_{VaR,t})$$

Representative Household

- Household solves

$$\max_{\{C_t, N_t, \omega_t\}} \mathbb{E}_t \left[\int_t^{\infty} e^{-\beta(s-t)} \left(\frac{C_s^{1-\gamma}}{1-\gamma} - \frac{N_s^{1+\xi}}{1+\xi} \right) ds \right]$$

subject to

$$\frac{dF_t}{F_t} = \left(i_t - \pi_t + \omega_t \mu_{banks,t} - \frac{1}{F_t} \left(C_t - (1 - s_t) \frac{W_t}{P_t} N_t + T_t \right) \right) dt + \omega_t \sigma_{banks,t} dB_t$$

- Households face complete markets
- Portfolio of bonds and stock of banks

Household's FOC Give IS Equation

- The household's stochastic discount factor is

$$Q_t^{house} = e^{-\beta t} C_t^{-\gamma}$$

- Household's Euler equation and market clearing $(C_t = Y_t)$ give IS curve

$$dy_t = \frac{1}{\gamma}\left(i_t - \pi_t - \beta + \frac{1}{2}\eta_t^2\right) dt + \frac{\eta_t}{\gamma} dZ_t$$

Household and Intermediaries Equalize Marginal Valuation

- Banks and household trade in complete markets implies $Q_t^{house} = Q_t^{bank}$
- Matching the volatility of Q_t^{house} and Q_t^{bank}

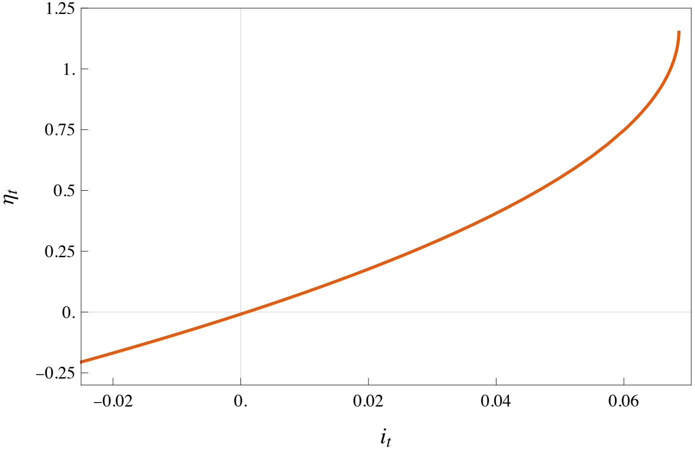
$$\underbrace{\frac{\eta_t}{\gamma}}_{\text{house portfolio risk}} = \underbrace{\frac{\eta_t - g_t}{\gamma_t}}_{\text{bank portfolio risk}} + \underbrace{g_t}_{\text{preference shock}} - \underbrace{stoch\left(d\log\left(\frac{1}{\beta} + 2\tau\lambda_t\right)\right)}_{\text{VaR constraint risk}}$$

we find a function G such that

$$\eta_t = G\left(i_t - \pi_t, s_t\right)$$

- Monetary policy impacts price of risk η_t via changes in i_t

Risk-Taking Channel of Monetary Policy



Change of Variables to Growth-at-Risk To Match Data

- To link to empirical findings, define "Growth-at-Risk"

$$
\begin{aligned}
GaR_t &\equiv VaR_{\tau,\alpha}\left(Y_t\right) \\
&= -\tau\mathbb{E}_t[dy_t/dt] - \mathcal{N}^{-1}(\alpha)\sqrt{\tau}Vol_t(dy_t/dt)
\end{aligned}
$$

- From the IS equation

$$
\mathbb{E}_t[dy_t/dt] = \frac{1}{\gamma}\left(i_t - \pi_t - \beta + \frac{1}{2}\eta_t^2\right)
$$

$$
Vol_t(dy_t/dt) = \frac{\eta_t}{\gamma}
$$

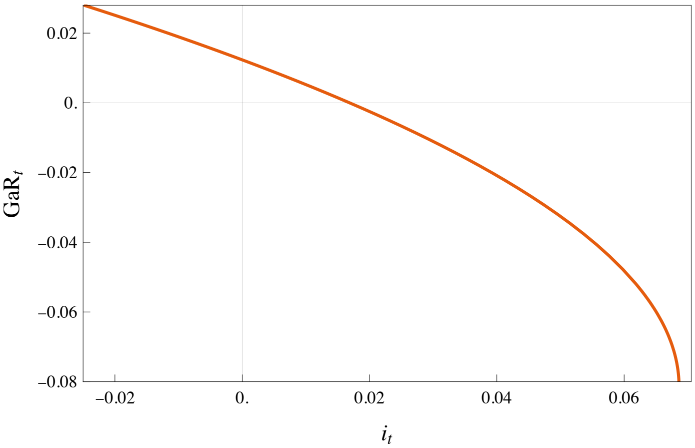
Risk-Taking Channel of Monetary Policy

- Plugging into GaR_t

$$
\begin{aligned}
GaR_t &= -\frac{\tau}{\gamma}\left(i_t - \pi_t - \beta + \frac{\mathcal{N}^{-1}(\alpha)}{\sqrt{\tau}}\left|\eta_t\right| + \frac{1}{2}\eta_t^2\right) \\
&= -\frac{\tau}{\gamma}\left(i_t - \pi_t - \beta + \frac{\mathcal{N}^{-1}(\alpha)}{\sqrt{\tau}}\left|G(i_t - \pi_t, s_t)\right| + \frac{1}{2}G(i_t - \pi_t, s_t)^2\right)
\end{aligned}
$$

- GaR_t and i_t are one-to-one: The risk-taking channel of monetary policy

Risk-Taking Channel of Monetary Policy



Power of Continuous Time

- Can solve banks' VaR problem in closed form (even if markets were incomplete)
- Linearizing drift and stochastic parts retains time variation in risk premium

$$dy_t = \frac{1}{\gamma}\left(i_t - i^* - \pi_t\right) dt + \xi(GaR_t - s_t) dZ_t$$

$$GaR_t = -\frac{1}{\gamma}(i_t - i^* - \pi_t)\tau - \mathcal{N}^{-1}(\alpha)\sqrt{\tau}\xi(GaR_t - s_t)$$

where ξ is a linearization constant

- Need at least 3rd order approximation in discrete time

NKV

$$
\begin{aligned}
\text{Dynamic IS:} \quad dy_t &= \frac{1}{\gamma}\left(i_t - i^* - \pi_t\right) dt + \xi(GaR_t - s_t) dZ_t \\
\text{Growth-at-Risk:} \quad GaR_t &= -\tau \mathbb{E}_t[dy_t/dt] - \mathcal{N}^{-1}(\alpha)\sqrt{\tau}\, Vol_t(dy_t/dt) \\
\text{Bank shocks:} \quad ds_t &= -\kappa\left(s_t - \bar{s}\right) + \sigma_s dZ_t \\
\text{NKPC:} \quad d\pi_t &= \left(\beta\pi_t - \kappa y_t\right) dt
\end{aligned}
$$

Optimal Monetary Policy Problem

- Central bank solves

$$L = \min_{\{y_s,\pi_s,i_s\}} \mathbb{E}_t \int_t^{\infty} e^{-s\beta}(y_s^2 + \lambda\pi_s^2)ds$$

subject to

$$\text{Dynamic IS:} \quad dy_t = \frac{1}{\gamma}(i_t - i^* - \pi_t)\,dt + \xi(GaR_t - s_t)dZ_t$$

$$\text{Growth-at-Risk:} \quad GaR_t = -\tau\mathbb{E}_t[dy_t/dt] - \mathcal{N}^{-1}(\alpha)\sqrt{\tau}Vol_t(dy_t/dt)$$

$$\text{Bank shocks:} \quad ds_t = -\kappa(s_t - \bar{s}) + \sigma_s dZ_t$$

$$\text{NKPC:} \quad d\pi_t = (\beta\pi_t - \kappa y_t)\,dt$$

Optimal Monetary Policy

- Optimal i_t satisfies augmented Taylor

$$i_t \quad = \quad \phi_0 + \phi_\pi \pi_t + \phi_y y_t + \phi_v GaR_t$$

- Or flexible inflation targeting

$$\pi_t = \psi_0 + \psi_y y_t + \psi_v GaR_t + \psi_s s_t$$

- Coefficients ϕ and ψ are a function of structural vulnerability parameters

Output Gap Mean-Volatility Tradeoff

- Eliminating i_t, dynamics of the economy are

$$dy_t = \xi\left(M\,GaR_t + \frac{\mathcal{N}^{-1}(\alpha)}{\sqrt{\tau}}s_t\right)dt + \xi\left(GaR_t - s_t\right)dZ_t$$

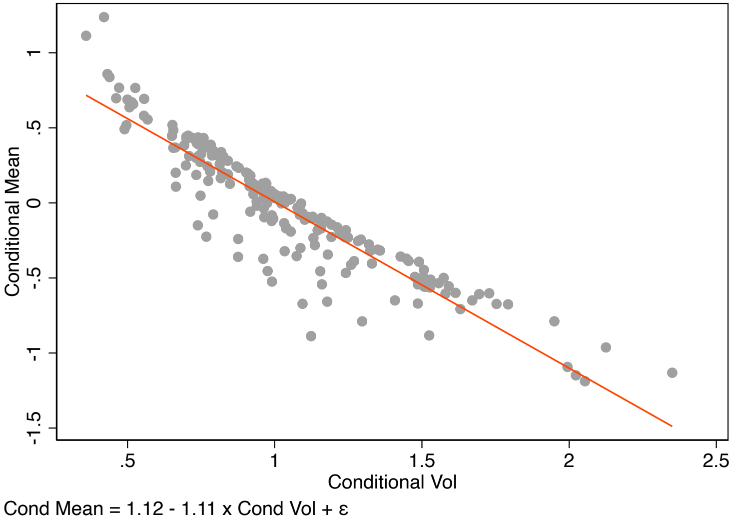
where

$$M \equiv -\frac{\xi + \mathcal{N}^{-1}(\alpha)\sqrt{\tau}}{\tau\xi}$$

is the slope of the mean-volatility line for output gap

$$\mathbb{E}_t\left[dy_t/dt\right] = M\,Vol_t\left(dy_t/dt\right) - \frac{1}{\tau}s_t$$

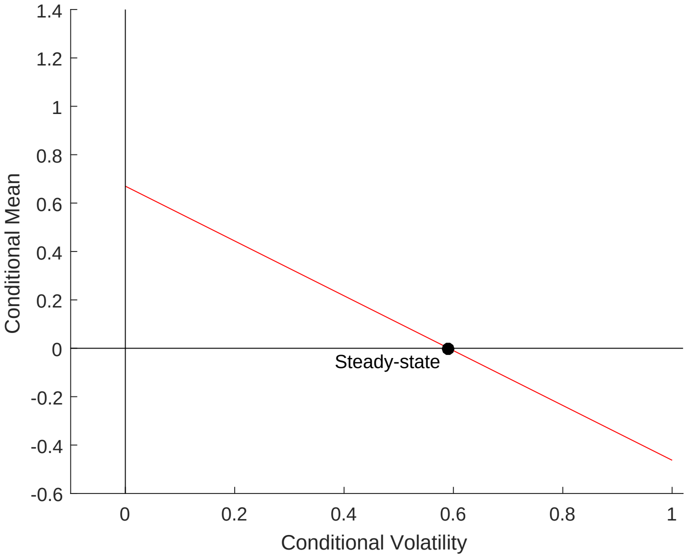
Recall Mean-Vol Line for Output Gap Growth



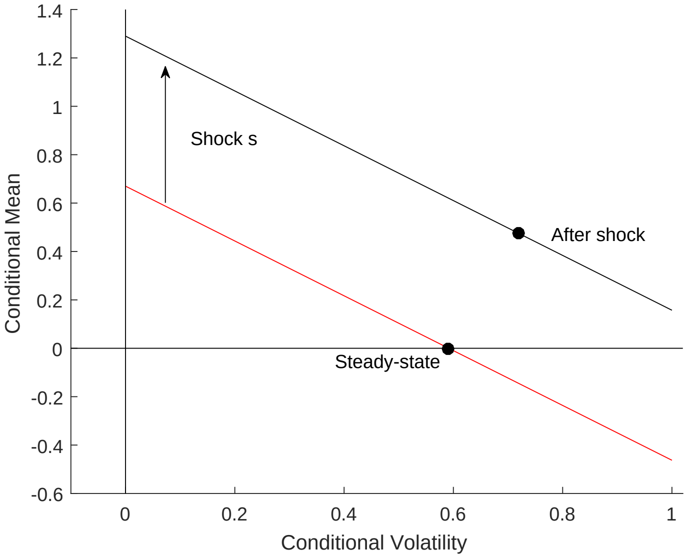
Mean-Vol Line Moments Pin Down New Parameters

- Use standard New Keynesian parameters when possible
- For parameters relating to vulnerability, match empirical and model-based regression of the conditional mean on the conditional vol of output gap growth
- Intercept, slope, standard deviation and AR(1) coefficient of residuals identify all new parameters

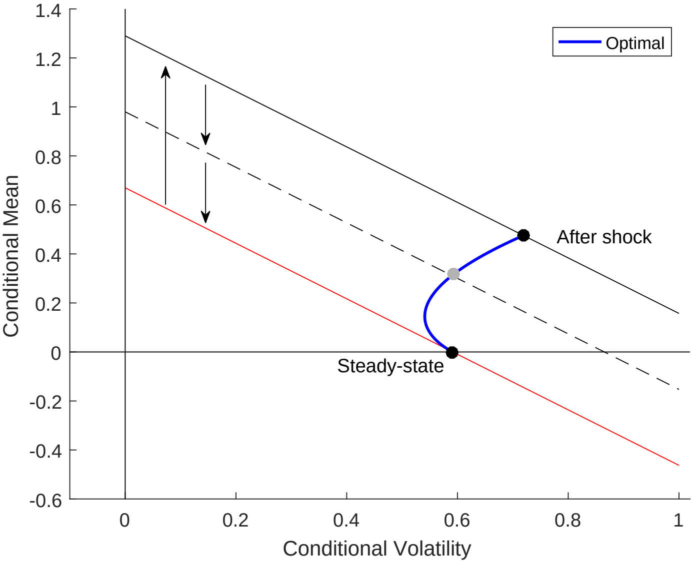
Dynamics After a Shock



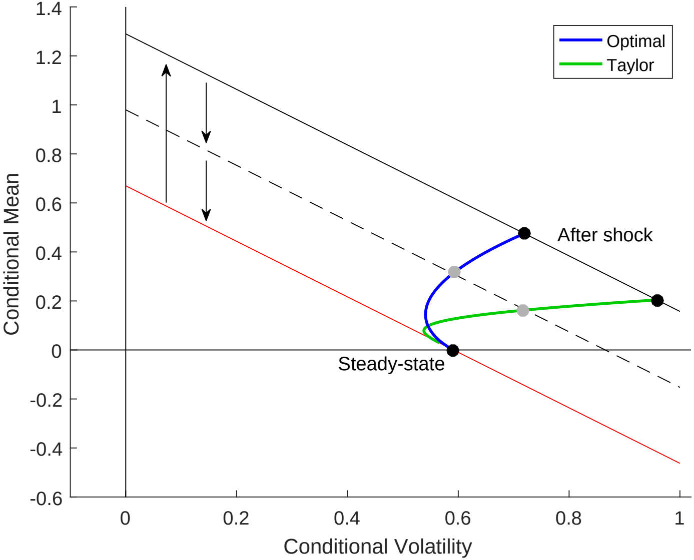
Dynamics After a Shock



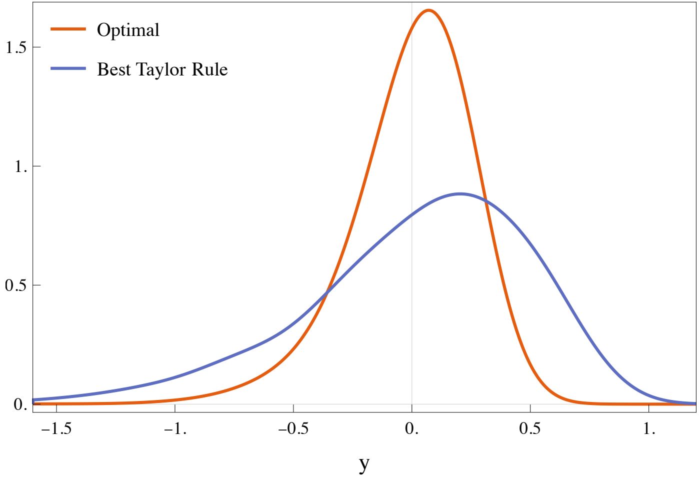
Dynamics After a Shock



Dynamics After a Shock



Welfare Gains: Steady State Distribution of Output Gap



Conclusion

- We augment the NK model with a financial sector with a Value-at-Risk constraint
- Model matches key empirical GaR patterns
- Mathematically tractable
- Optimal monetary policy always conditions on vulnerability
  - Vulnerability responds to monetary policy
  - LAW or clean up after crisis depending on vulnerability
  - Magnitudes are quantitatively large