Financial Vulnerability and Monetary Policy

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July 2018

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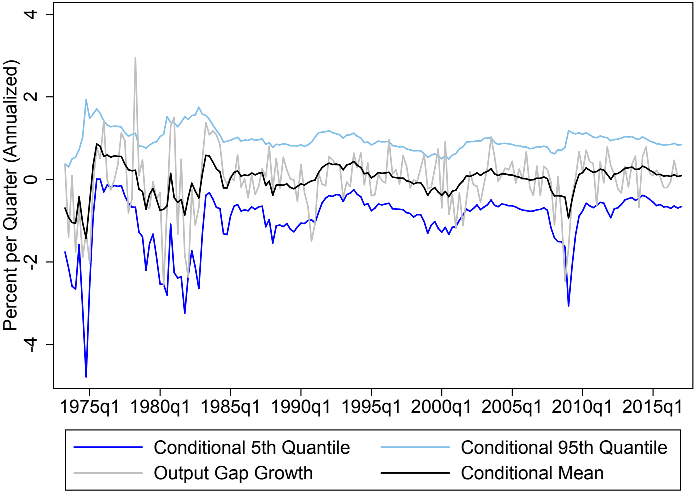
Financial vulnerability: Amplification mechanisms in the financial sector

Two questions are hotly debated

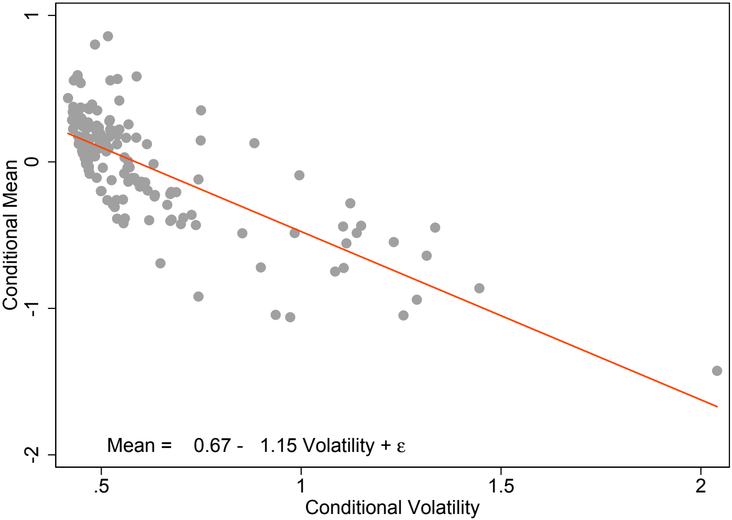
1. Does monetary policy impact the degree of financial vulnerability?
2. Should monetary policy take financial vulnerability into account?

Financial Variables Predict Tail of Output Gap Distribution

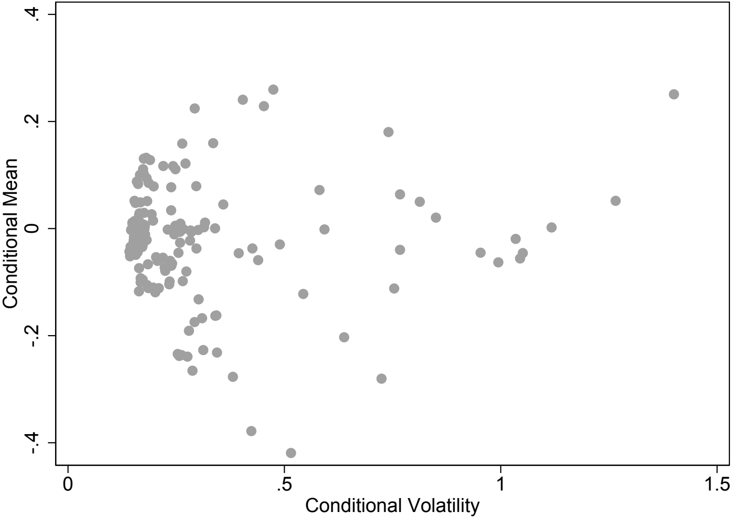
Based on “Vulnerable Growth” by Adrian, Boyarchenko and Giannone (AER, 2018)



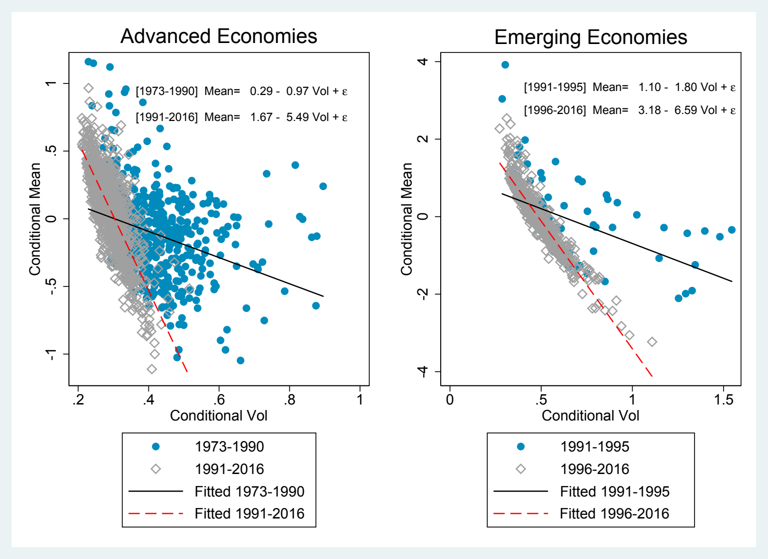
Conditional Mean-Volatility Line for Output Gap Growth



Conditional Mean-Volatility Relation for Inflation



Patterns Hold in Panel of Countries



Overview of Microfounded Non-Linear Model

- Firm optimization gives standard New Keynesian Phillips Curve
- Households are 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 among themselves and with households
  - 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: Browninan motion Z_t
- Real risk-free rate is R_t
- A state price density (SPD) is a process with $Q_0 \equiv 1$ and

$$\frac{dQ_t}{Q_t} \equiv -R_t dt - \eta_t dZ_t$$

such that for all assets j

$$S_{j,t} = \frac{1}{Q_t}\mathbb{E}_t\left[\int_t^\infty Q_s D_{j,s} ds\right]$$

where η_t is the “market price of risk”

- Expected excess returns μ_t, volatility σ_t and $\eta_t = \sigma_t^{-1}\mu_t$

The Intermediation Sector Setup

- Each "bank" solves a standard Merton portfolio choice problem augmented by a Value-at-Risk constraint and preference shocks

$$
\begin{aligned}
V\left(X_t\right) &= \max_{\{\theta_t,\delta_t\}} \mathbb{E}_t\left[\int_t^{\infty} e^{-\beta(u-t)} e^{\zeta_u} \log\left(\delta_u X_u\right) du\right] \\
& s.t. \\
\frac{dX_t}{X_t} &= \left(R_t - \delta_t + \theta_t \mu_t\right) dt + \theta_t \sigma_t dZ_t \\
VaR_{\tau,\alpha}\left(X_t\right) &\leq a_V X_t \\
d\zeta_t &= -\frac{1}{2} s_t^2 dt - s_t dZ_t \\
ds_t &= -\kappa(s_t - \bar{s}) + \sigma_s dZ_t
\end{aligned}
$$

The Intermediation Sector Setup

$$V\left(X_t,t\right) = \max_{\{\theta_t,\delta_t\}} \mathbb{E}_t^{bank}\left[\int_t^{\infty} e^{-\beta(u-t)}\log\left(\delta_u X_u\right)du\right]$$

$$s.t.$$

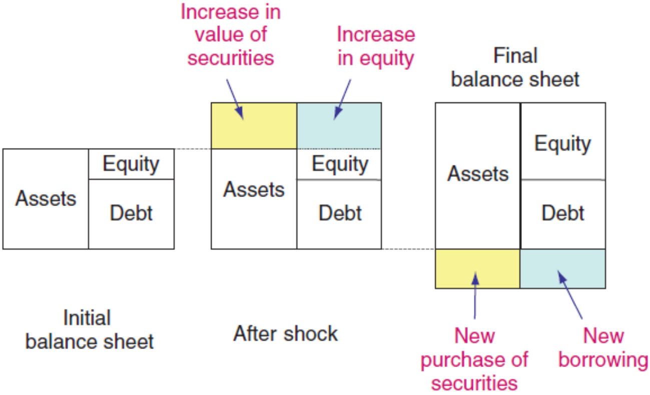
$$\frac{dX_t}{X_t} = \left(R_t-\delta_t+\theta_t\mu_t-\theta_t\sigma_t s_t\right)dt+\theta_t\sigma_t dZ_t^s$$

$$VaR_{\tau,\alpha}\left(X_t\right) \leq a_V X_t$$

$$ds_t = -\kappa(s_t-\bar{s})+\sigma_s dZ_t^s$$

The Banks' VaR Constraint and Amplification

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



Optimal Portfolio and Dividends

The optimal portfolio is characterized by

$$\theta_t = \frac{1}{\gamma_t}(\mu_t/\sigma_t^2 - s_t/\sigma_t)$$

$$\delta_t = u(\gamma_t)\beta$$

$$\gamma_t \in (1,\infty) \text{ such that: } VaR_{\tau,\alpha}(X_t) = X_t a_V$$

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

State-Price Density of Intermediaries

- Lagrange multiplier of VaR is increasing in η_t and γ_t

$$\lambda_{VaR,t} = G(\eta_t, \gamma_t, s_t)$$

- The marginal value of one unit of wealth is

$$\begin{aligned} Q_t^{bank} &= e^{\zeta_t} e^{-\beta t} (\delta_t X_t)^{-1} (1 - \lambda_{VaR,t}) \\ &= e^{\zeta_t} e^{-\beta t} (\delta_t X_t)^{-1} (1 - G(\eta_t, \gamma_t, s_t)) \end{aligned}$$

Representative Household

- Household solves

$$\max_{\{C_t, N_t, \omega_t\}} \mathbb{E}_t \left[\int_t^{\infty} e^{-\beta(u-t)} \left(\frac{C_u^{1-\sigma}}{1-\sigma} - \frac{N_u^{1+\varsigma}}{1+\varsigma} \right) du \right]$$

subject to

$$d(P_t F_t) = W_t N_t dt - P_t C_t dt + \omega_t d(P_t S_t)$$

$$\omega_{goods,t} = 0$$

Households and Intermediaries Agree on Pricing

- The household's SPD is

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

- The household's Euler equation and market clearing ($C_t = Y_t$) give the IS equation

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

where i_t is the nominal interest rate

Households and Intermediaries Agree on Pricing

- Banks and households trading in complete markets means marginal utilities agree $Q_t^{house} = Q_t^{bank}$
- Matching the volatility of Q_t^{house} and Q_t^{bank}

$$\eta_t = \eta(\gamma_t, s_t) = \eta(V_t, s_t)$$

where

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

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

$$dy_t = \frac{1}{\gamma}\left(i_t - r - \pi_t\right) dt + \xi(V_t - s_t) dZ_t$$

$$V_t = -\tau(i_t - r - \pi_t)/\gamma - \mathcal{N}^{-1}(\alpha)\sqrt{\tau}\xi(V_t - s_t)$$

- Need at least 3rd order approximation in discrete time

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

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

The Optimal Monetary Policy

- Augmented Taylor

$$\begin{aligned} i_t &= \phi_0 + \phi_\pi \pi_t + \phi_y y_t + \phi_v V_t \\ &= \Phi(V_t) \end{aligned}$$

- Or flexible inflation targeting

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

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

Risk-Taking Channel of Monetary Policy

- Fixed prices for simplicity ($\pi = 0$)
- Using the IS equation

$$dy_t = \frac{1}{\gamma}(i_t - r)\,dt + \xi(V_t - s_t)\,dZ_t$$

- We can plug

$$\mathbb{E}_t[dy_t/dt] = \frac{1}{\gamma}(i_t - r)$$

$$Vol_t(dy_t/dt) = \xi(V_t - s_t)$$

into

$$V_t \quad = -\tau\mathbb{E}_t[dy_t/dt] - \mathcal{N}^{-1}(\alpha)\sqrt{\tau}Vol_t(dy_t/dt)$$

to see that V_t and i_t are one-to-one: The *risk-taking channel* of monetary policy

Output Gap Mean-Volatility Tradeoff

- Eliminating i_t, dynamics of the economy are

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

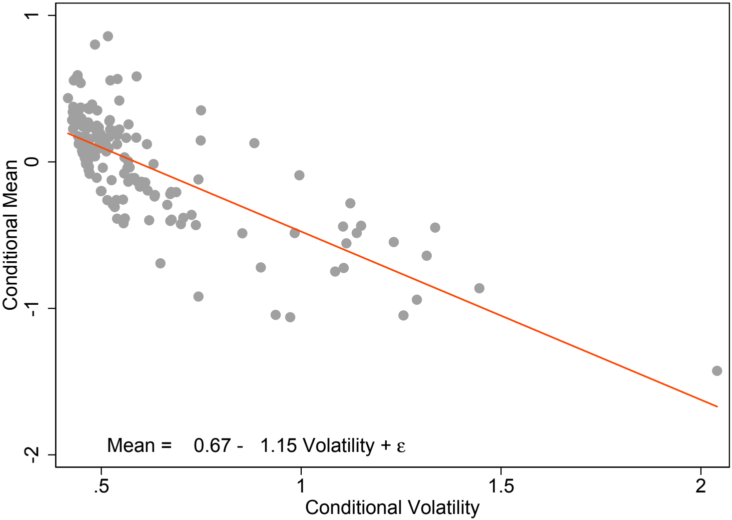
where

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

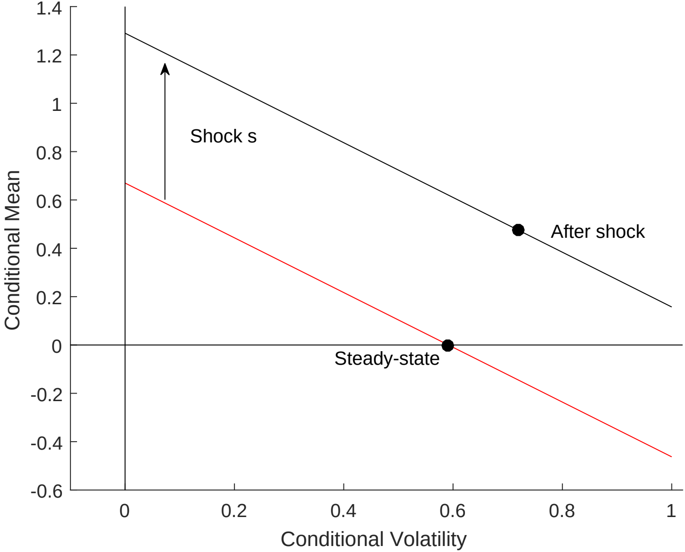
is the slope of the mean-volatility line for output gap

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

Recall Mean-Vol Line for Output Gap Growth



Model Produces Mean-Vol Line for Output Gap Growth



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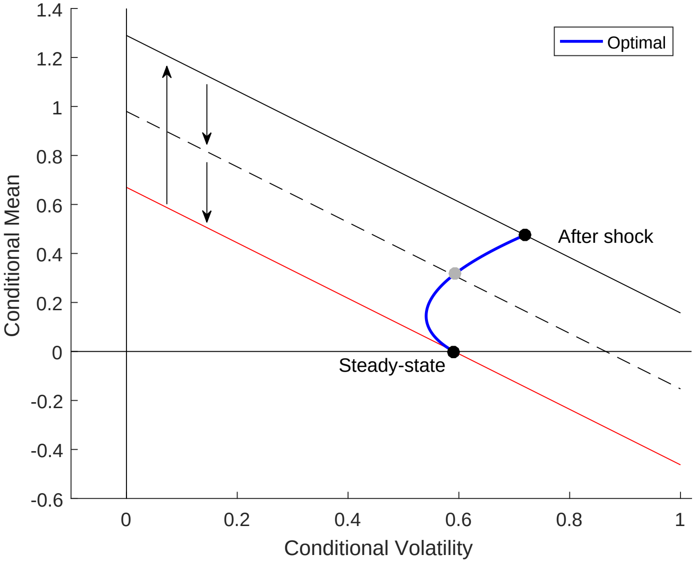

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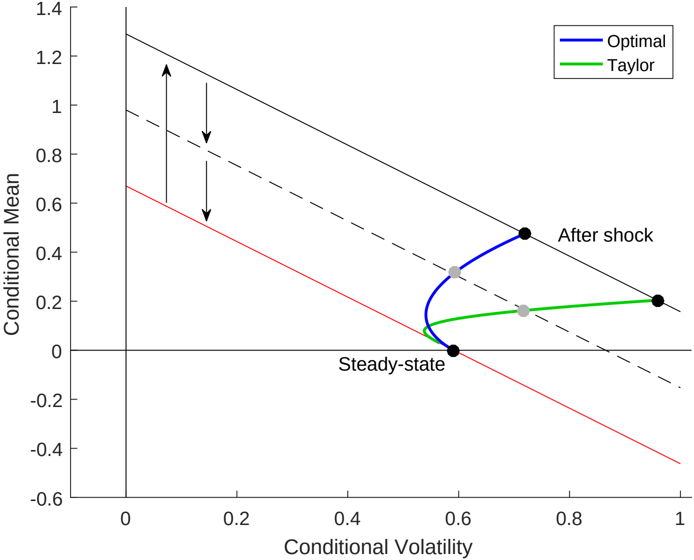
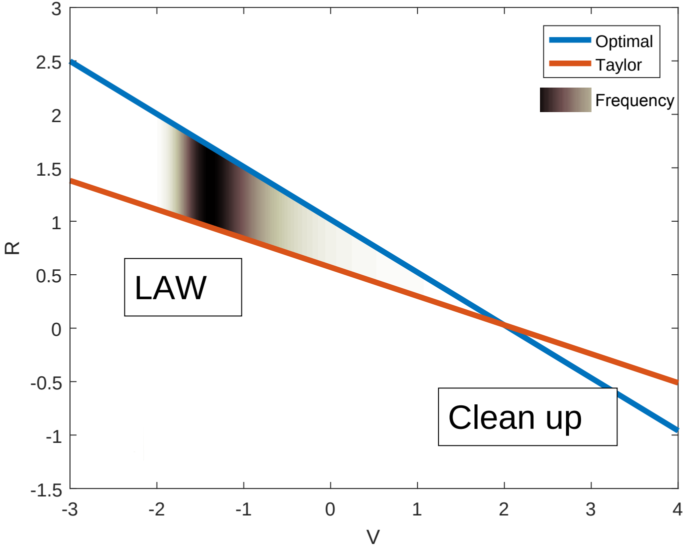


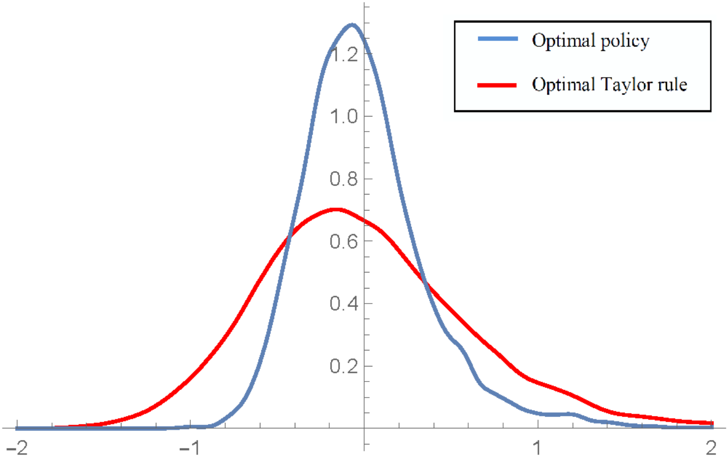
Calibration

- 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

Interest Rate Response to Vulnerability



Welfare Gains: Steady State Distribution of Output Gap



Conclusion

- The NK model can be augmented by
  - A financial sector that intermediates subject to a Value-at-Risk constraint
  - Shocks to financial sector
- Matches the stylized fact that conditional upper GDP quantiles are constant, while lower GDP quantiles move with financial conditions
- Mathematically tractable
- Optimal monetary policy always depends on vulnerability
  - Optimal monetary policy conditions on vulnerability
  - Vulnerability responds to monetary policy
  - LAW or clean up after crisis depending on vulnerability
  - Magnitudes are potentially large quantitatively