Financial Vulnerability and Monetary Policy

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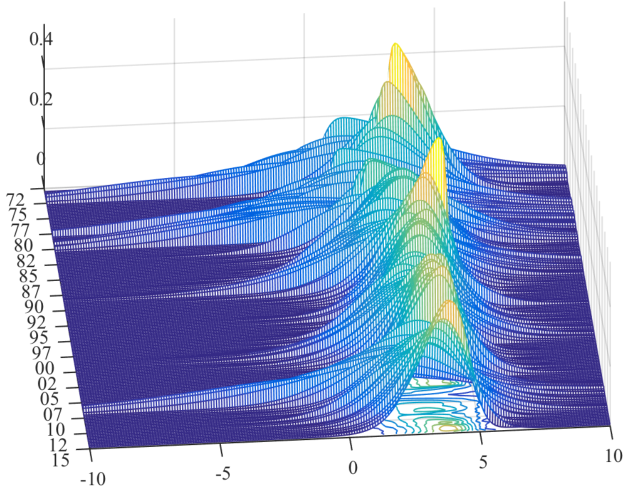
Financial vulnerability: Amplification mechanisms in the financial sector

Two questions are hotly debated

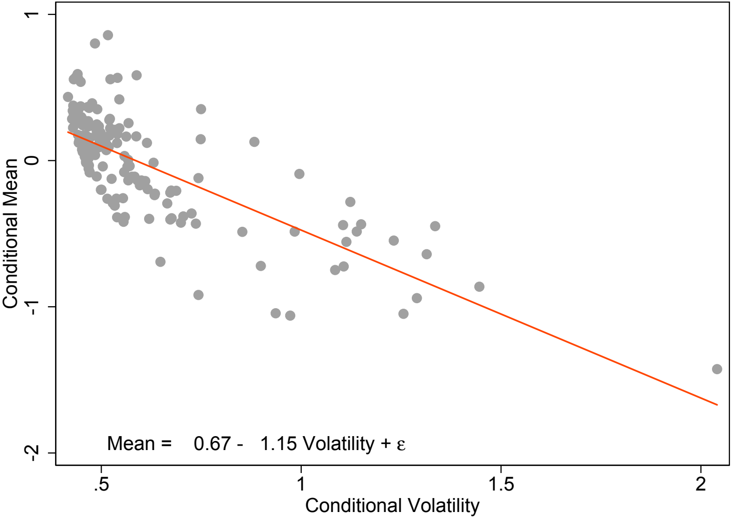
1. Does monetary policy impact the degree of financial vulnerability?
2. Should monetary policy take financial vulnerability into account?

Financial Variables Predict Tail of GDP Distribution

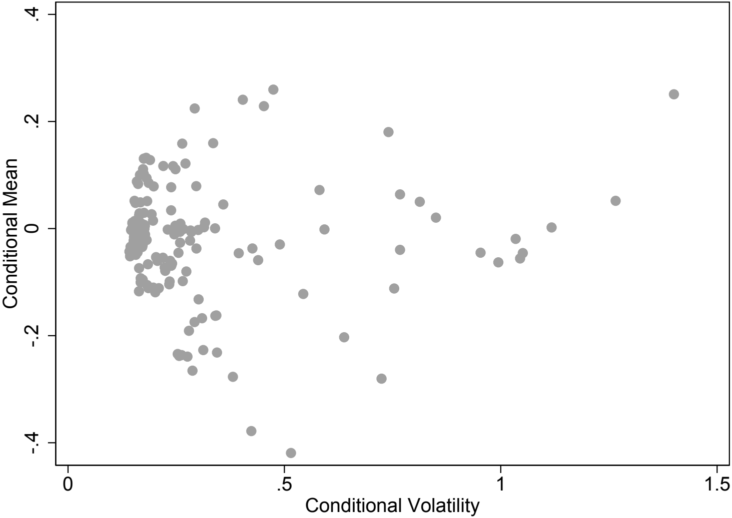
"Vulnerable Growth" by Adrian, Boyarchenko and Giannone (2016)



Conditional Mean-Volatility Line for Output Gap Growth



Conditional Mean-Volatility Relation for Inflation



Overview of Microfounded Non-Linear Model

- Firms are exactly as in basic New Keynesian model
- Households are as in New Keynesian model but
    - Cannot finance firms directly
    - Trade other financial assets (stocks, riskless desposits) with banks
- Banks
    - Finance firms
    - Trade financial assets among themselves and with households
    - Less risk averse than household
    - 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"

Firms are Standard New Keynesian

- Linear production for good i: $Y_t(i) = N_t(i)$
- Monopolistically competitive on differentiated goods, Calvo pricing
- The FOC for intermediate good producers linearized around deterministic steady sate gives the standard New Keynesian Phillips Curve

$$d\pi_t = (\beta\pi_t - \kappa y_t)\,dt$$

The Intermediation Sector Setup

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

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

The Intermediation Sector Setup

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

$$s.t.$$

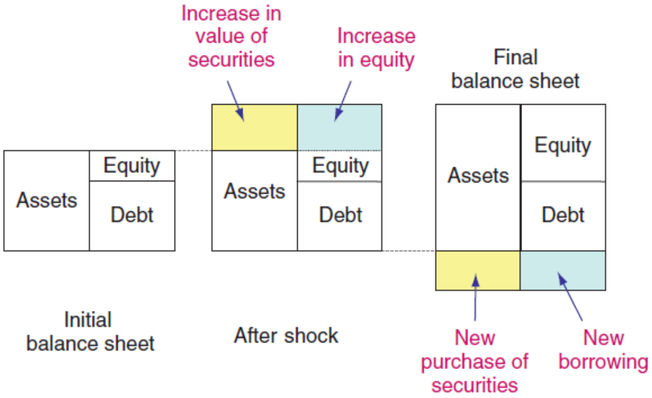
$$\frac{dX_t}{X_t} = \left(R_t - \delta_t + \theta_t \mu_t - \theta_t \sigma_t s_t\right) dt + \theta_t \sigma_t dZ_t^s$$

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

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

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

The optimal portfolio is characterized by

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

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

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

$$\text{or } \gamma_t = 1 \text{ otherwise}$$

Representative Household

- Household solves

$$\max_{\{C_t, N_t, \omega_t\}_{t \geq s}} \mathbb{E}_s \left\{ \int_s^\infty e^{-\beta(t-s)} \left(\frac{C_t^{1-\sigma}}{1-\sigma} - \frac{N_t^{1+\varsigma}}{1+\varsigma} \right) dt \right\}$$

subject to

$$d\left(P_t F_t\right) \leq W_t N_t dt - P_t C_t dt + \omega_t d\left(P_t S_t\right)$$

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

Euler Equation and Price of Risk

- The household's Euler equation gives IS curve

$$dy_t = \frac{1}{\gamma}(i_t - r - \pi_t)\,dt + \frac{\eta_t}{\gamma} dZ_t$$

- Banks and households trading in complete markets means marginal utilities agree, which together with market clearing give

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

where

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

Optimal Monetary Policy

- Focus on simpler case with no direct impact of monetary policy on γ_t: Mechanism is through general equilibrium (prices of risk) only
- Abstract from Phillips Curve (fixed prices)
- General case still linear-quadratic, can be solved in closed form

Optimal Monetary Policy

- Central bank solves

$$L = \min_{\{i_s\}_{s=t}^{\infty}} \mathbb{E}_t \int_t^{\infty} e^{-s\beta} y_s^2 ds$$

subject to

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

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

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

Optimal Monetary Policy

- Linearize stochastic part; keeps time variation in risk premium
- Central bank solves

$$L = \min_{\{i_s\}_{s=t}^{\infty}} \mathbb{E}_t \int_t^{\infty} e^{-s\beta} y_s^2 ds$$

subject to

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

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

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

Optimal Monetary Policy

- 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

- i_t and V_t are one-to-one, so think of V_t as central bank's choice
- Eliminating i_t, dynamics of the economy are

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

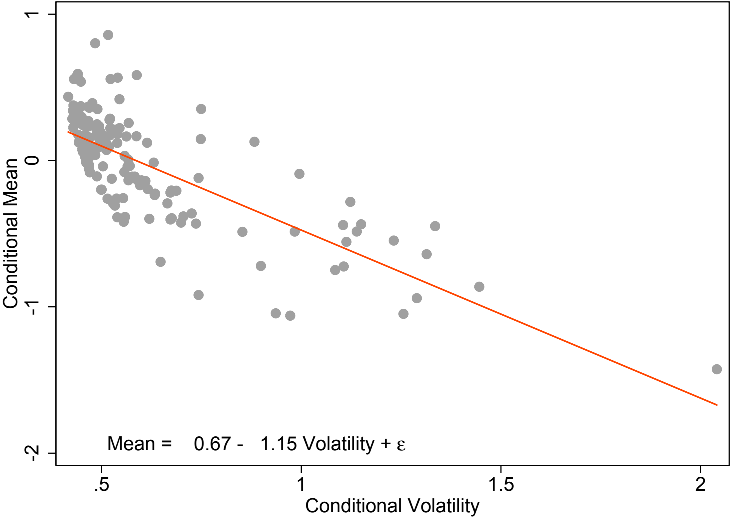
where

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

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

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

Conditional Mean-Volatility Line for Output Gap Growth



Tradeoff for Monetary Policy

- Negative slope gives $M < 0$ and mean variance tradeoff:

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

- Changes in V_t move the economy along the mean-vol line
- Full stabilization ($y_t = 0$) made impossible by vulnerability
- Shocks s_t shift the line up and down
- Because $M < 0$, we have $\partial V_t / \partial R_t < 0$: Tighter policy reduces vulnerability

The Optimal Monetary Policy

- Re-introduce Phillips Curve
- Augmented Taylor

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

- Can be expressed as flexible inflation targeting

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

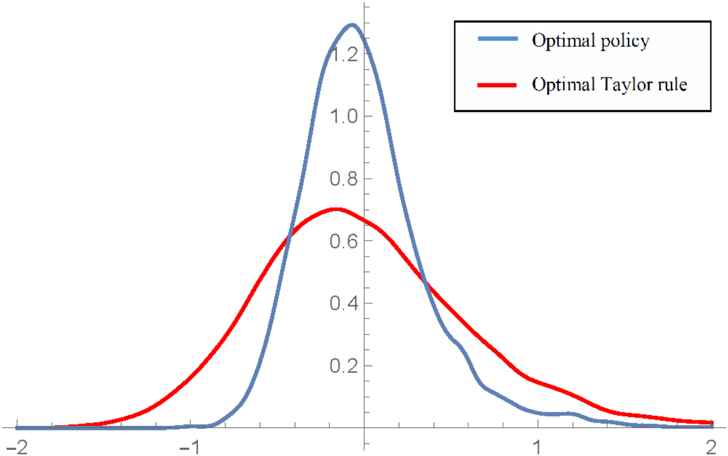
- Coefficients ϕ and ψ are a function of structural parameters that govern vulnerability
- Strict inflation targeting not feasible

Calibration

- Calibration comes directly from a regression of the conditional mean on the conditional vol of output gap growth
- Pick $\beta = 0.01, \alpha = 5\%, \tau = 1$ and match intercept, slope, standard deviation and AR(1) coefficient of residuals to get

$$
\begin{aligned}
\xi &= 0.36 \\
\bar{s} &= -0.67 \\
\sigma_s &= 0.61 \\
\kappa &= 2.14
\end{aligned}
$$

Welfare Gains



Conclusion

- The NK model can be augmented by
  - A financial sector that intermediates subject to a Value-at-Risk constraint
  - Shocks to financial sector
- The "second order" linearization approximation
  - 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
  - Vulenrability responds to monetary policy
  - Magnitudes are potentially large quantitatively