Macroeconomic and Financial Risks: A Tale of Mean and Volatility

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Motivation

"Therefore, the Committee's policy decisions reflect its longer-run goals, its medium-term outlook, and its assessments of the balance of risks, including risks to the financial system that could impede the attainment of the Committee's goals."

Statement on Longer-Run Goals and Monetary Policy Strategy, FOMC 01/31/23

- Evidence of risk management considerations in one-third of the FOMC monetary policy decisions between 1993 and 2008. (Evans et al., 2015)

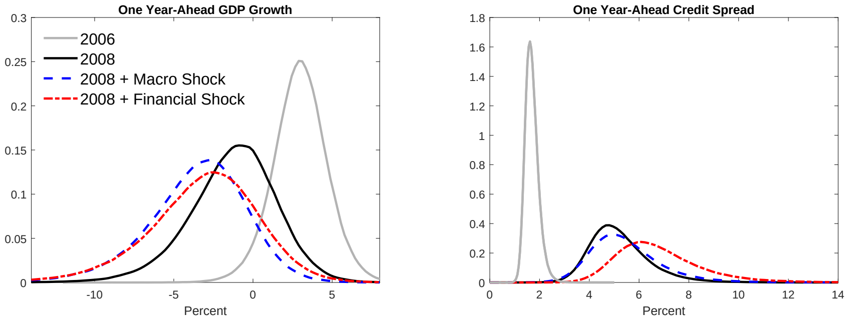
Introduction

This paper

- This paper investigates the drivers of uncertainty and tail risk of future economic conditions (GDP growth) and future financial conditions (corporate credit spreads) in the U.S. using a stochastic volatility VAR.
- We distinguish between shocks originating in the real economy and shocks originating in the financial sector.
  - We impose sign and zero restrictions on structural coefficients to identify macroeconomic and financial shocks.

Introduction

The impact of macro and financial shocks on conditional distributions



- Adverse macroeconomic and financial shocks move simultaneously future GDP growth and corporate spreads.
- Shocks generate an increase in uncertainty and downside risk of future GDP growth and spreads, but small reduction in upside risk.
- Effect of macroeconomic shocks is largest within the first year, while financial shocks play a dominant role at longer horizons.

Introduction

Decomposing the Effects of Shocks on Uncertainty and Tail Risk

- We estimate the model using Bayesian techniques and compute conditional distributions as in Del Negro and Schorfheide (2013).
- We use these conditional distributions to compute impulse responses of uncertainty and tail risk.
- We decompose the effects of our identified shocks into three channels:
  - **Volatility channel:** Shocks alter the evolution of current and future volatilities of shocks.
  - **Estimation uncertainty channel:** Parameter and state uncertainty make the effects of shocks more uncertain.
  - **"Higher-order" channel:** Interaction between shocks and time-varying volatility beyond the direct effect of shocks on current and future volatility.

Contribution to Literature

- Growth-at-Risk: ABG (2019), Plagborg-Moller et al. (2020).
- SV-VARs to estimate mean effects of time-varying volatility: Mumtaz and Zanetti (2013), Creal and Wu (2017), Carriero et al. (2018), Mumtaz (2018), Shin and Zhong (2018).
- Linear VARs to examine the relationship between uncertainty and the business cycle: Bloom (2009), Baker et al. (2016), LMN (2021).
- Nexus between macroeconomic and financial conditions: Bernanke et al. (1999), Gertler and Karadi (2011), Bocola (2016), Guerrieri and Iacoviello (2017).

Plan for talk

1. Econometric Framework
2. Identification Strategy
3. Effects of Shocks on Uncertainty and Tail Risk
4. Concluding Remarks

Multivariate SV-VAR model

We use the model of Mumtaz (2018).

Level equation: Stochastic Volatility & Volatility-in-mean

$$z_t = c + \sum_{j=1}^{P} \beta_j z_{t-j} + \sum_{k=1}^{K} b_k \tilde{h}_{t-k} + H_t^{1/2} e_t$$

$$H_t = \exp\left(diag\left(\tilde{h}_t\right)\right)$$

Volatility equation: Endogenous Volatility

$$\tilde{h}_t = \alpha + \sum_{j=1}^{J} \theta_j \tilde{h}_{t-j} + \sum_{q=1}^{Q} d_j z_{t-j} + S^{1/2} \eta_t$$

Covariance structure: Correlated level and volatility disturbances

$$\varepsilon_t = \begin{pmatrix} e_t \\ \eta_t \end{pmatrix} \sim N(0, \Sigma); \quad \Sigma = \begin{pmatrix} \Sigma_\eta & \Sigma'_{\eta e} \\ \Sigma_{\eta e} & \Sigma_e \end{pmatrix}$$

Details

Model Specification and Estimation

Model specification

- Level equation: 4 lags level; 2 lags volatility
- Volatility equation: 2 lags level; 1 lag volatility

Data

- GDP growth, BAA 10-Year Spreads — 1947:Q2 – 2019:Q4

Estimation

- Use 1947:Q2 - 1953:Q1 as pre-sample to calibrate prior distributions
- 150,000 draws (50,000 burn-in)

Understanding the Conditional Distribution

- We can write the conditional distribution as:

$$p\left(z_{t+1:t+f}|z^t\right) = \int_{\Theta}\int_{H_t}\left[\int_{H_{t+1:t+f}} p\left(z_{t+1:t+f}, H_{t+1:t+f}|z^t, H_t, \Theta\right) dH_{t+1:t+f}\right] p\left(H_t|z^T, \Theta\right) p\left(\Theta|z^T\right) dH_t d\Theta.$$

Sources of uncertainty

- Future realizations of shocks
- Unobserved volatility states
- Parameters of the model

- These sources of uncertainty have implications for the overall uncertainty and tail behavior of the conditional distribution.

Uncertainty and Tail Risk Impulse Responses

From the conditional distributions, we compute:

- $UIR_f[z_i|z^t, \nu^*_{j,t+1}] = \sqrt{Var[z_{i,t+f}|z^t, \nu^*_{j,t+1}]} - \sqrt{Var[z_{i,t+f}|z^t]}$
  (Uncertainty Impulse Response)

- $SFIR_f[z_i|z^t, \nu^*_{j,t+1}] = SF_f[z_i|z^t, \nu^*_{j,t+1}] - SF_f[z_i|z^t]$
  (Shortfall Impulse Response)

- $LRIR_f[z_i|z^t, \nu^*_{j,t+1}] = LR_f[z_i|z^t, \nu^*_{j,t+1}] - LR_f[z_i|z^t]$
  (Longrise Impulse Response)

Uncertainty, shortfall, and longrise impulse responses integrate over the states H^t and parameters Θ.

Shortfall & Longrise

Identification Strategy

Sign and zero restrictions on the contemporaneous elasticities to identify macroeconomic and financial shocks...

$$
\begin{aligned}
z_{GDP,t} &= \underbrace{\eta_{12}}_{<0} z_{CS,t} + \underbrace{\eta_{13}}_{(-1;1)} h_{GDP,t} + \underbrace{\eta_{14}}_{=0} h_{CS,t} + \nu_{M,t}, \\
z_{CS,t} &= \underbrace{\eta_{21}}_{<0} z_{GDP,t} + \underbrace{\eta_{23}}_{(-0.5;0.5)} h_{GDP,t} + \underbrace{\eta_{24}}_{=0} h_{CS,t} + \nu_{F,t}.
\end{aligned}
$$

- SR on Relationship between GDP growth and spreads.
- BR on Impact of GDP growth volatility on GDP growth and spreads.
- ZR on financial volatility.

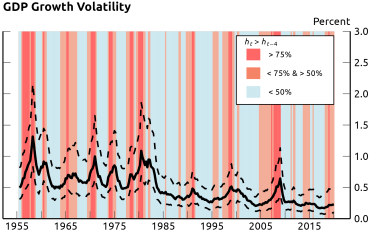
Identification Strategy (2)

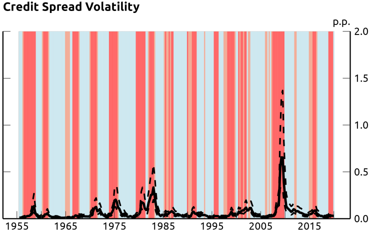
... and macroeconomic and financial volatility shocks.

$$\begin{aligned} h_{GDP,t} &= \underbrace{\eta_{31}}_{<0} z_{GDP,t} + \underbrace{\eta_{32}}_{>0} z_{CS,t} + \underbrace{\eta_{34}}_{=0} h_{CS,t} + \nu_{MV,t}, \\ h_{CS,t} &= \eta_{41} z_{GDP,t} + \eta_{42} h_{GDP,t} + \eta_{43} h_{GDP,t} + \nu_{FV,t}. \end{aligned}$$

- SR on Endogenous component of GDP growth volatility.
- Separating financial and financial volatility shocks.

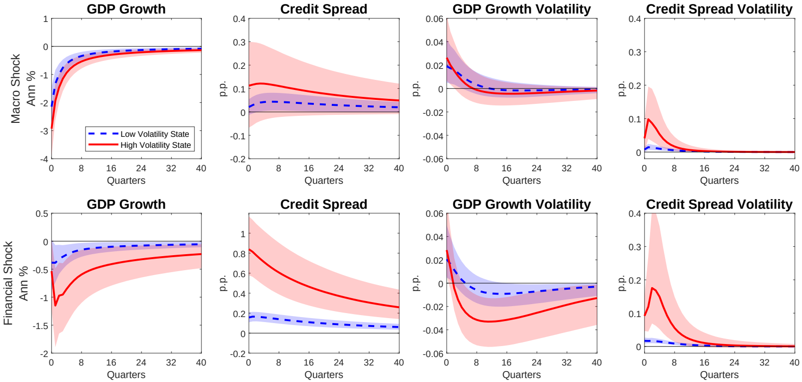
Volatility of GDP Growth and Credit Spreads





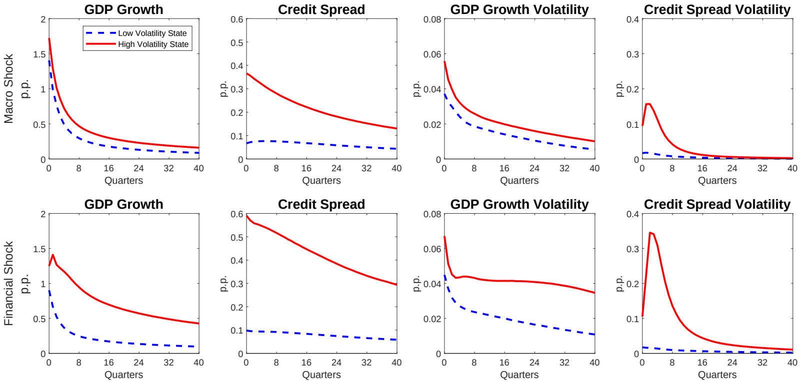
- Estimation uncertainty is large for GDP growth volatility.
- Volatility is counter-cyclical.
- Strong evidence of rising volatility around recessions.

Impulse Response Functions



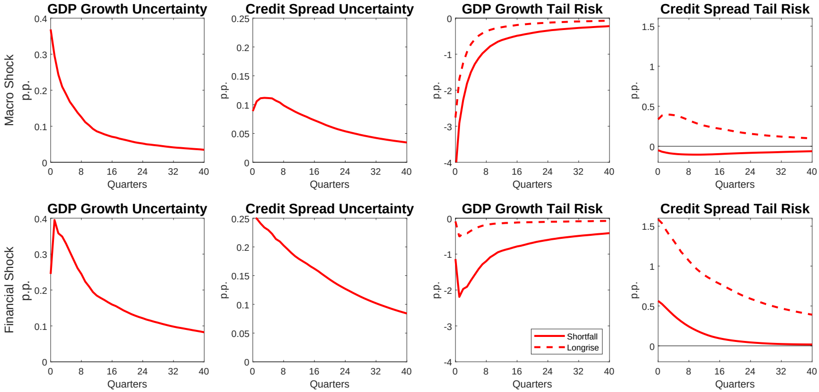
- Both shocks generate business cycle correlations: GDP growth declines while corporate spreads and the volatility processes rise.
- Amplification from high volatility state is larger for financial shocks.
- Credible sets are wide and also get amplified by the volatility state.

Credible Sets of Impulse Response Functions



- For all variables, the width of the credible set is of comparable size to the response itself.
- High volatility greatly amplifies uncertainty surrounding the effects of both shocks.

Effects of Shocks on Uncertainty and Risk

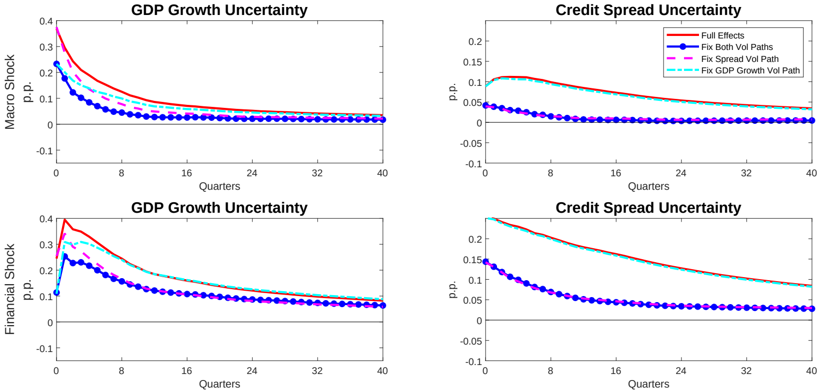


- Relative impact of macro shocks is largest within the first year while financial shocks are more important at longer horizons.
- The tails capturing adverse risks move by more than the tails measuring upside risk.

Asymmetric Effects

Decomposing the Channels of Transmission

Volatility Channel



- Keeping the volatility of GDP growth innovations fixed lowers GDP growth uncertainty.
- Keeping the volatility of spread innovations fixed lowers both GDP growth and credit spread uncertainty.

Concluding Remarks

- We analyze uncertainty and tail risk around economic and financial forecasts using a SV-VAR model estimated with Bayesian methods.
- Identified macro and financial shocks by imposing sign and zero restrictions.
- Macro shocks have significant impact on uncertainty and downside risk at shorter horizons, while financial shocks account for most of the variation at longer horizons.

Comparison with Other Series Alternative Identification Strategies

APPENDIX

Univariate SV-VAR Model

Level equation

$$z_t = c + \beta z_{t-1} + b_1 \tilde{h}_{t-1} + H_t^{1/2} e_t$$

$$H_t = \exp\left(\tilde{h}_t\right)$$

Volatility equation

$$\tilde{h}_t = \alpha + \theta \tilde{h}_{t-1} + d_1 z_{t-1} + S^{1/2} \eta_t$$

Covariance structure

$$\begin{pmatrix} e_t \\ \eta_t \end{pmatrix} \sim N\left(0, \Sigma\right); \quad \Sigma = \begin{pmatrix} 1 & \zeta \\ \zeta & 1 \end{pmatrix}$$

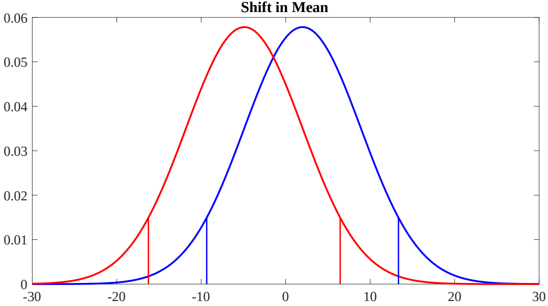
Return

Univariate SV-VAR Model

Homoskedastic VAR

$$z_t = c + \beta z_{t-1} + \exp\left(\frac{1}{2}\alpha\right) e_t$$

$$e_t \sim N(0, 1)$$



- Shifts in mean generate time variation in expected shortfall...
- But expected shortfall and longrise shift in lockstep.
- No time variation in variance.

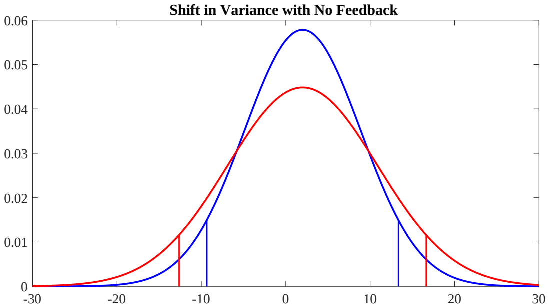
Univariate SV-VAR Model

SV with no Feedback

$$z_t = c + H_t^{1/2} e_t, \;\; H_t = \exp\left(\tilde{h}_t\right)$$

$$\tilde{h}_t = \alpha + \theta \tilde{h}_{t-1} + S^{1/2} \eta_t$$

$$\begin{pmatrix} e_t \\ \eta_t \end{pmatrix} \sim N\left(\begin{pmatrix} 0 \\ 0 \end{pmatrix}, \begin{pmatrix} 1 & 0 \\ 0 & 1 \end{pmatrix}\right)$$



- Shifts in variance generate time variation in expected shortfall...
- But expected shortfall and longrise move symmetrically.
- e_t and η_t shift mean and variance independently.

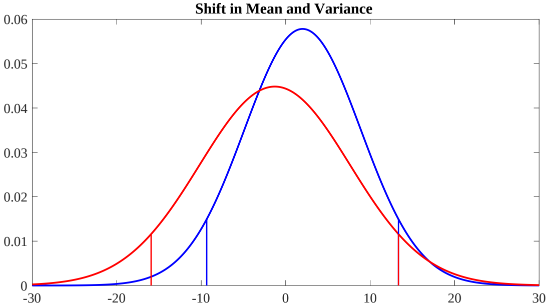
Univariate SV-VAR Model

Full SV Model

$$z_t = c + \beta z_{t-1} + b_1 \tilde{h}_{t-1} + H_t^{1/2} e_t, \; H_t = \exp\left(\tilde{h}_t\right)$$

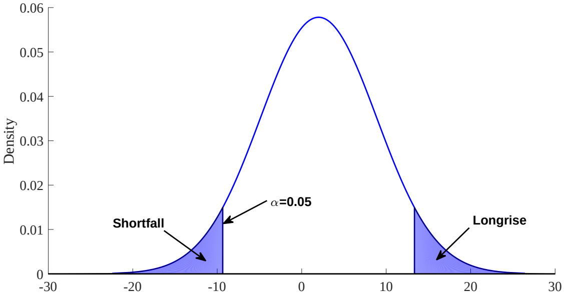
$$\tilde{h}_t = \alpha + \theta \tilde{h}_{t-1} + d_1 z_{t-1} + S^{1/2} \eta_t$$

$$\begin{pmatrix} e_t \\ \eta_t \end{pmatrix} \sim N\left(\begin{pmatrix} 0 \\ 0 \end{pmatrix}, \begin{pmatrix} 1 & \zeta \\ \zeta & 1 \end{pmatrix}\right)$$



- Shifts in mean and variance generate asymmetric time variation in shortfall and longrise.
- e_t and η_t can shift both mean and variance. Return

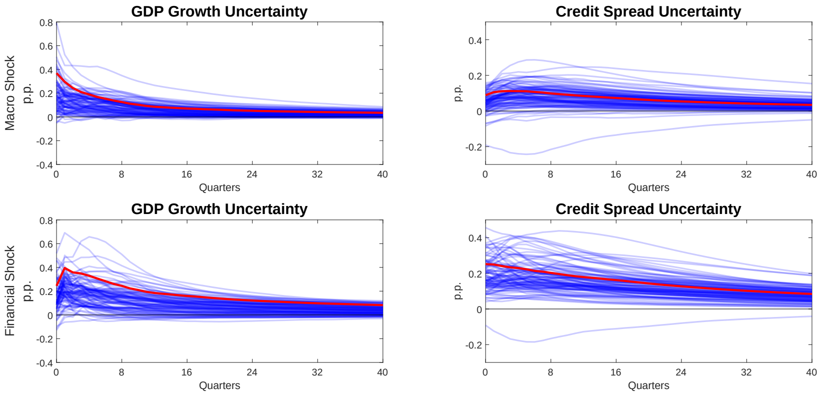
Definition of Risk similar to ABG



- Downside risk: $SF = E\left[z|z < q_{\alpha}(z)\right]$ (Expected shortfall)
- Upside risk: $LR = E\left[z|z > q_{1-\alpha}(z)\right]$ (Expected longrise) Return

Decomposing the Channels of Transmission

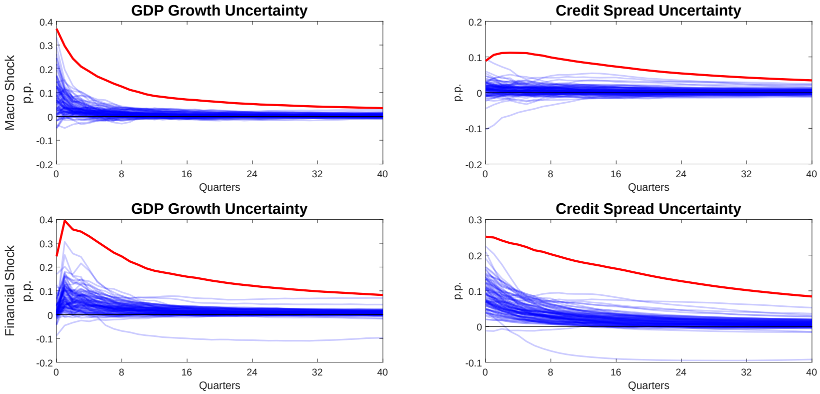
Estimation Uncertainty Channel



- Importance of estimation uncertainty is largest at short horizons, when shocks have their largest effects.

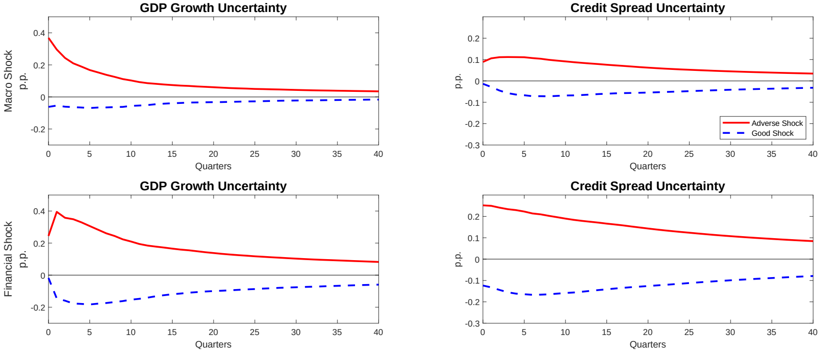
Decomposing the Channels of Transmission

Higher-Order Channel



- **Example:** Credit spreads are positively correlated with credit spread volatility.
  - A shock jumping off from a baseline of low credit spreads has smaller effects relative a shock from a baseline of high credit spreads.

Asymmetric Effects of Bad Versus Good Shocks

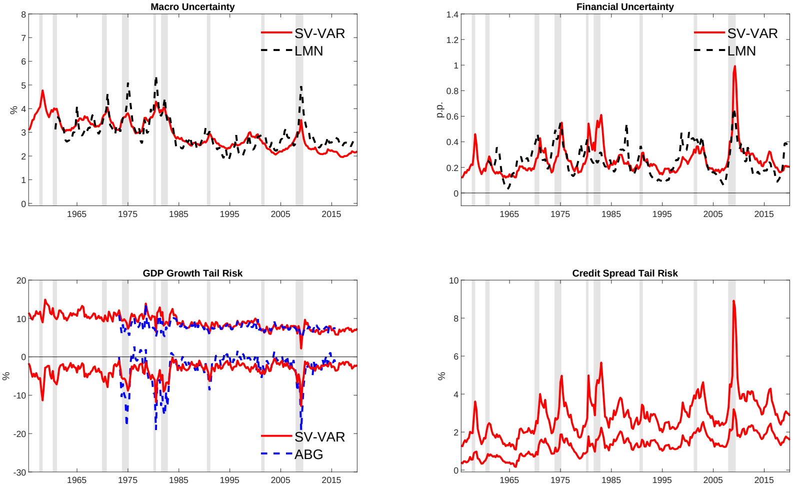


- Shocks that move log volatility symmetrically have asymmetric effects on uncertainty.
- Estimation uncertainty increases overall uncertainty no matter whether the shock is positive or negative.

Return

Additional Results and Validation

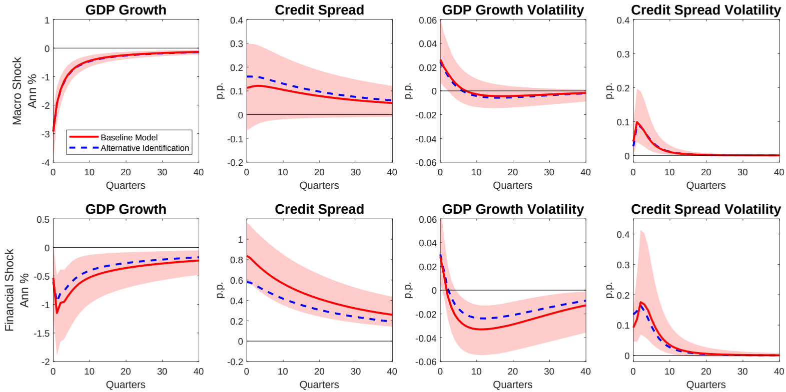
Comparison with other Time Series Measures of Uncertainty and Risk



Return

Additional Results and Validation

Alternative Identification Scheme



- We employ an alternative identification scheme that assumes financial shocks are mediated through financial volatility instead of credit spreads.

Return