Uncertainty shocks as second-moment news shocks

David Berger, Ian Dew-Becker, and Stefano Giglio

Introduction

- Uncertainty about the economy varies over time and is countercyclical
- Large literatures in **macro** and **finance** have explored theoretically and empirically the importance of uncertainty shocks
- **This paper**: what happens to the economy when aggregate uncertainty is high?
  - E.g. Brexit, debt ceiling debates, Euro crisis

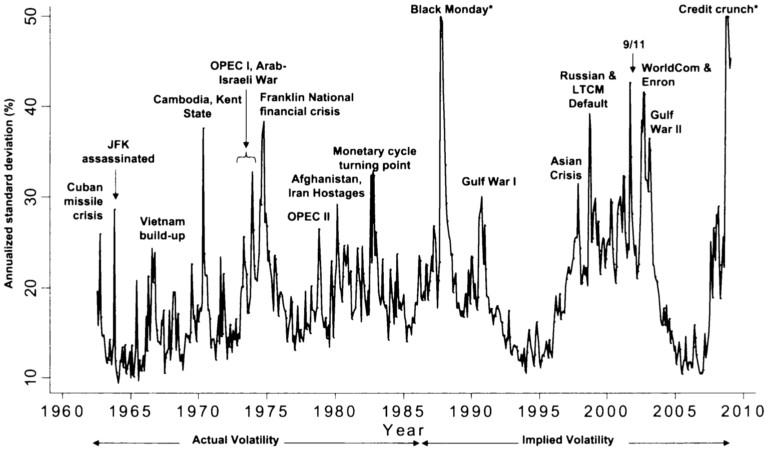
Introduction

- **Identification** issue: uncertainty often high after large shocks
- First-moment shocks and second-moment shocks are correlated
  - Brexit, 9/11 maybe bad news on their own
- Key point: distinguish two factors
  1. Uncertainty – expect large shocks in the future
  2. Realized volatility – large shocks today

Models

- This distinction is fundamental in both finance and macroeconomic models
- Example: macro models
  - Option-value, wait-and-see effects
  - Precautionary saving
  - Discount rates/risk premia
- All driven by **uncertainty about the future**

Bloom (2009) uncertainty shocks



Preview of the results

- Asset pricing: investors want to hedge jumps (RV) not changes in uncertainty
- Macro: identified uncertainty shocks have no negative effects on the economy
  - Existing literature does not control for the occurrence of bad shocks (RV)
- Model with negative skewness can explain the empirical patterns

$$E\left[\varepsilon^3\right] < 0 \Rightarrow cov\left(\varepsilon, \varepsilon^2\right) < 0$$

Outline

1. The macro effects of realized volatility and uncertainty
    - Preliminary evidence
    - Identification
    - Empirical results
2. The price of realized volatility and uncertainty shocks
3. The "Really Skewed Business Cycle" model

Preliminary evidence

Realized volatility vs. uncertainty

- We want to distinguish the realization of a shock ε_t from the uncertainty about future realizations of that shock
- Long literature on current vs. expected first-moment shocks:

$$\varepsilon_t \quad vs \quad E_t\left[\varepsilon_{t+n}\right]$$

- Same applies to second moments:

$$\varepsilon_t^2 \quad vs \quad E_t\left[\varepsilon_{t+n}^2\right]$$

- **Realized volatility** (ε_t^2) captures the realization of squared shocks
- **Uncertainty** ($E_t\left[\varepsilon_{t+n}^2\right]$) capture the expected future volatility

Preliminary evidence

	Employment		Industrial Production	
v_1	-0.10**	0.05	-0.09*	0.16
	(0.04)	(0.07)	(0.05)	(0.12)
rv		-0.14**		-0.23*
		(0.07)		(0.13)

- Regress output on current and lagged RV and expected volatility
- Potential problems with this simple regression
  - No dynamics
  - No identification of structural shocks
  - No output variance decomposition

Empirical Model

Notation

- s_t: log stock index (focus is S&P 500 uncertainty)
- $r_t = s_t - s_{t-1}$: log stock return
- For sufficiently short time periods (e.g. days), $E_t r_{t+1} \approx 0$, so

$$\begin{aligned} Var_t\left[s_{t+n}\right] &= E_t\left[\sum_{j=1}^{n} r_{t+j}^2\right] + E_t\left[\sum_{j=1}^{n} r_{t+j}\right]^2 \\ &\approx E_t\left[\sum_{j=1}^{n} r_{t+j}^2\right] = E_t \sum_{j=1}^{n} RV_{t+j} \end{aligned}$$

- Construct monthly series of RV

$$RV_t \equiv \sum_{days \in t} r^2$$

First- vs second-moment news

- First moment impact and news shocks:

$$\begin{aligned} \text{Impact shock:} \quad & tfp_t - E_{t-1}\left[tfp_t\right] \\ \text{News shock:} \quad & E_t tfp_{t+n} - E_{t-1} tfp_{t+n} \end{aligned}$$

- Second-moment impact and news shocks:

$$\begin{aligned} \text{RV shock:} \quad & RV_t - E_{t-1} RV_t \\ \text{Uncertainty shock} \quad : \quad & \left[E_t \sum_{j=1}^{24} RV_{t+j} - E_{t-1} \sum_{j=1}^{24} RV_{t+j}\right] \end{aligned}$$

- The two shocks are correlated $\Rightarrow$ Identification
- The two (correlated) shocks can be estimated from a VAR

Estimating the shocks using a VAR

- Estimate VARs of the form

$$\begin{bmatrix} RV_t \\ Y_t \end{bmatrix} = C + F(L) \begin{bmatrix} RV_{t-1} \\ Y_{t-1} \end{bmatrix} + \varepsilon_t$$

Y_t includes real activity and variables that forecast future vol.

- MA representation of VAR:

$$\begin{aligned} \begin{bmatrix} RV_t \\ Y_t \end{bmatrix} &= (I - F(1))^{-1} C + B(L)\varepsilon_t \\ B(L) &\equiv (I - F(L))^{-1} \end{aligned}$$

- RV shock is just the first shock in ε_t

- Uncertainty shock:

$$E_t \sum_{j=1}^{n} RV_{t+j} - E_{t-1} \sum_{j=1}^{n} RV_{t+j} = \left(e_1 \sum_{j=0}^{n-1} B_j \right) \varepsilon_t$$

$e_1 \equiv [1, 0, 0, ...]$

Identification

Identification of the uncertainty shock

- Both the RV shock and the uncertainty shock are linear combinations of the VAR errors
- **Identify the uncertainty shock by orthogonalizing it to the RV shock**
  - Equivalent to timing restriction: *as if* RV "moves first"
  - RV shock has effect on impact and on expectations of future RV (uncertainty)
  - Only shock we identify is the uncertainty shock: **pure news** about future RV
- What is this identification capturing, and does it make sense?
- Note: later on we relax it

Identification of the uncertainty shock

- **Concern**: what if uncertainty affects realized volatility on impact?
  - Uncertainty affects prices, and RV are just prices squared!
- However, RV is quadratic in the stock price
  - High uncertainty $\rightarrow$ low price $\rightarrow$ high RV
  - Low uncertainty $\rightarrow$ high price $\rightarrow$ high RV
- **Impact of uncertainty on RV is exactly zero on average when uncertainty is linear in the price**
- It's zero or very small in all models

Three structural models

- Simulate three models: real options (Bloom et al. (2017)), New Keynesian (Basu and Bundick (2017)), RSBC (this paper)
- Correlation of VAR-identified uncertainty shock with structural uncertainty shock:

Bloom et al.	Basu and Bundick	RSBC
0.94	0.94	0.91

- Correlation of structural uncertainty shock with *RV* (identifying assumption):

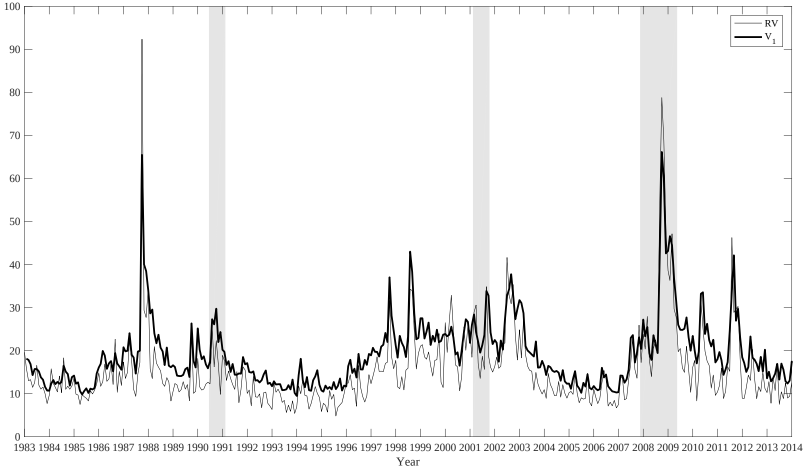
Bloom et al.	Basu and Bundick	RSBC
-0.01	-0.10	0.00

Data

Data

- Sample period: 1983–2014
- Real activity: Industrial production, employment, fed funds rate
  - Similar results with FAVAR
- Stock returns: S&P 500
- Info about future volatility: S&P 500 options from the CME, 1983–2014
  - Do not assume options reveal *objective* uncertainty; just provide info.
  - Options drive out other predictors

Time series of RV and market expectations

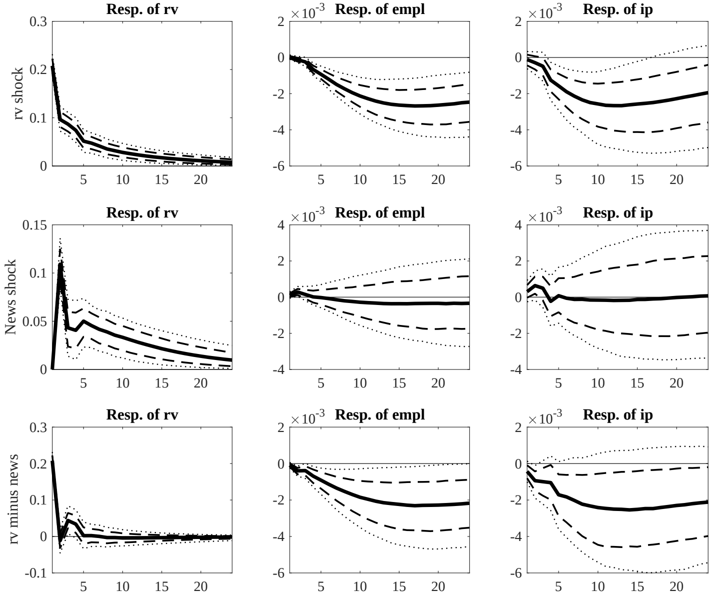


Empirical results

Simple Correlations

	Employment		Industrial Production	
v_1	-0.10**	0.05	-0.09*	0.16
	(0.04)	(0.07)	(0.05)	(0.12)
rv		-0.14**		-0.23*
		(0.07)		(0.13)

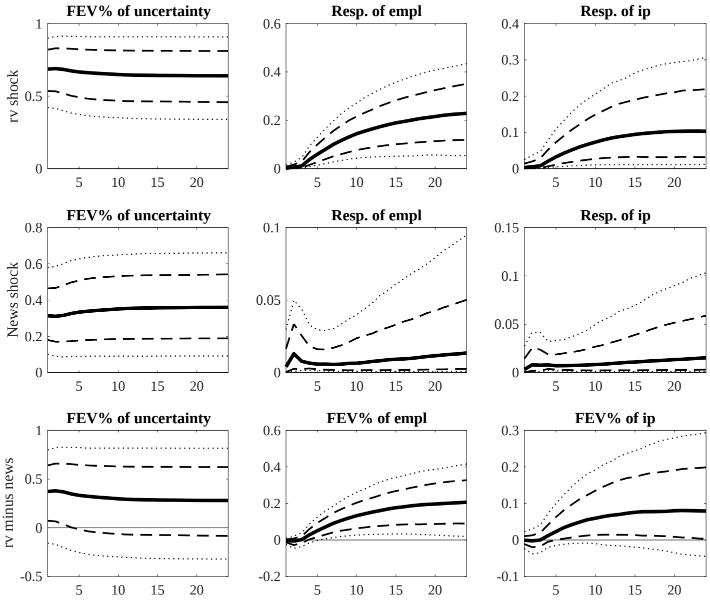
Impulse response functions



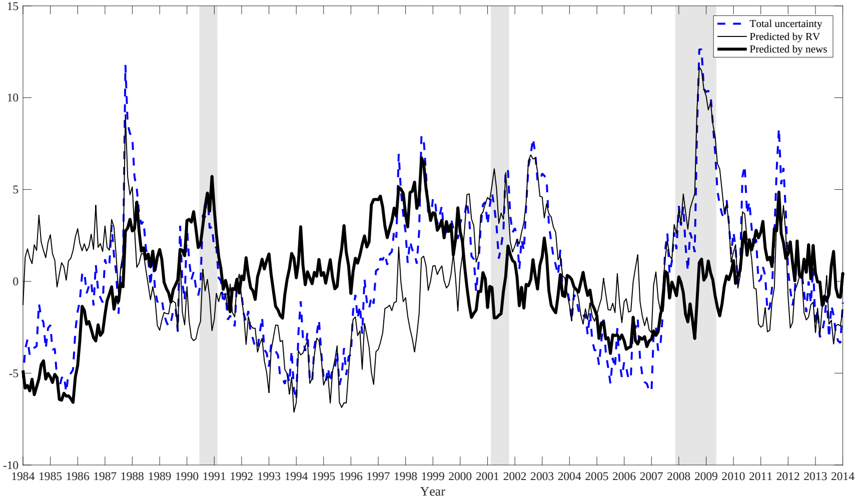
Summary

- IRFs are scaled so that the two shocks have same cumulative effect on future RV
- Both represent **equally large uncertainty shocks**
- RV shock (realization + uncertainty) $\Rightarrow$ contractionary
- Uncertainty alone $\Rightarrow$ not contractionary
- Difference between the two for future real activity is significant

Forecast error variance decompositions



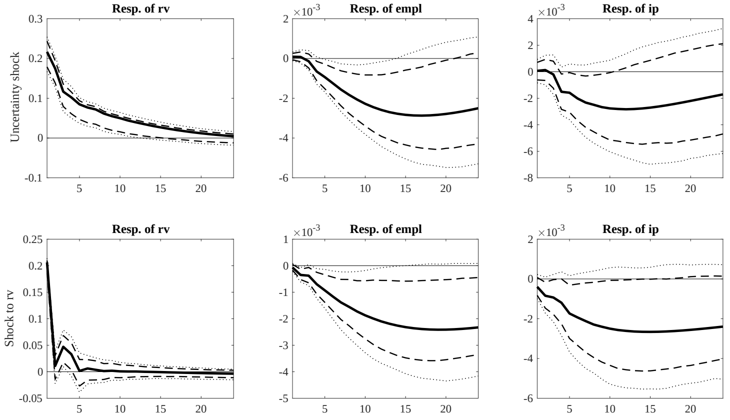
Fitted Uncertainty



Robustness

- Results qualitatively and quantitatively similar when we:
  - Order RV and EV last in VAR
  - Use quarterly data, alternative measures of activity
  - Change sample to 1988–2007 (drop 1987 crash and financial crisis)
  - Levels vs. logs
  - Control for S&P 500 return
  - Use jumps and negative returns only for RV
  - FAVAR
  - Use LASSO or Bayesian specification that relaxes timing assumption
  - Completely unrestricted
  - Detrending, backward-looking HP filter

EV first, RV second



Asset pricing evidence: S&P 500

"The Price of Variance Risk": Dew-Becker, Giglio, Le, Rodriguez (2017)

Asset pricing evidence

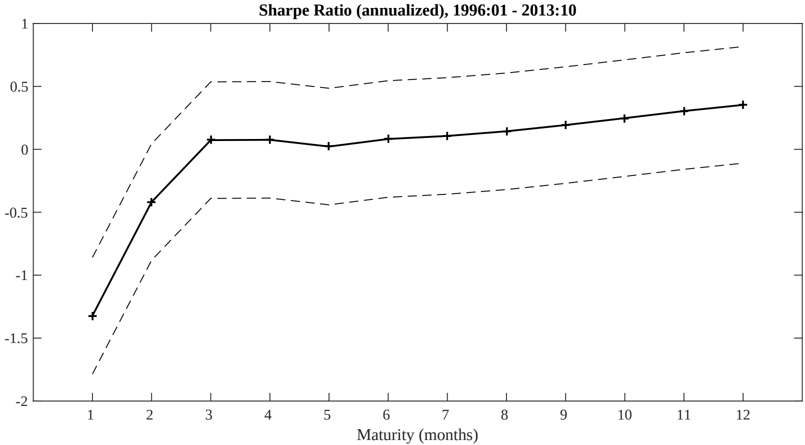
- Using derivatives, it is possible to hedge RV and uncertainty separately
  - Variance swap: pays sum of daily squared log S&P 500 returns
  - Straddles (one call and one put option)
  - Construct portfolios to hedge RV and uncertainty only
- Magnitude of returns reflects what investors have paid to hedge these shocks

$$SR = \frac{E_t\left[R_{t+1} - R_{f,t+1}\right]}{SD_t\left[R_{t+1}\right]} = -corr_t\left(R_{t+1}, MU_{t+1}\right) \times std\left(MU_{t+1}\right)$$

Asset pricing evidence

1. **Short-term variance forward**
   - Pay fixed amount in month t, receive RV_{t+1} in next month
   - Insurance against high RV_{t+1}
2. **Long-term variance forward**
   - Buy claim to RV_{t+12} in month t, sell in $t+1$
   - Insurance against *change in volatility expectations*

Sharpe ratios on variance forwards



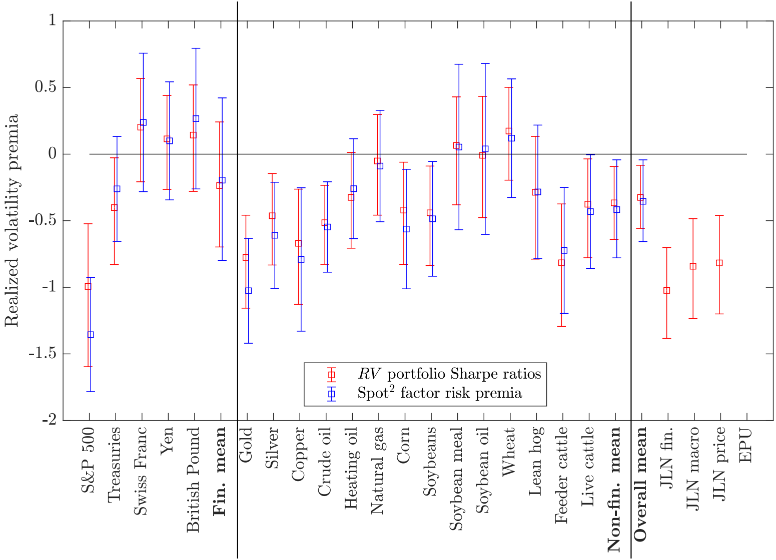
Asset pricing evidence: CME options

"Hedging macroeconomic and financial uncertainty and volatility": Dew-Becker, Giglio, Kelly (2018)

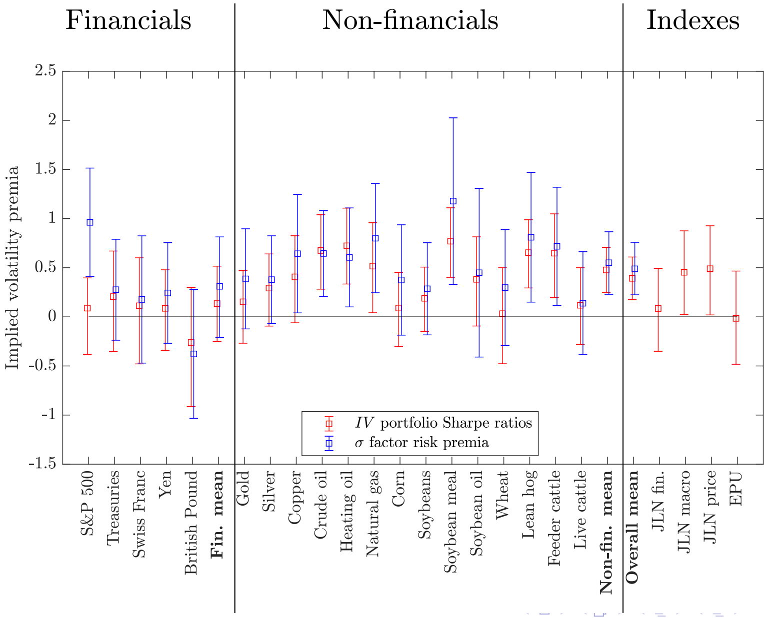
Hedging macroeconomic uncertainty

- Everything so far has focused on the S&P 500
- How about **macroeconomic uncertainty** more broadly?
- Can't hedge that directly
- Construct RV and uncertainty hedging portfolios for 19 underlyings traded at the CME
- Many of them more directly macro-related
- Hedges uncertainty in each commodity and, indirectly, macroeconomic uncertainty

Hedging macroeconomic RV: Sharpe ratios



Hedging macroeconomic uncertainty: Sharpe ratios



RBC model with RV and EV shocks

- Goal: simple model consistent with results
  - Illustrate how results can be rationalized
- Key idea: contractionary RV consistent with negatively skewed tech. shocks
  - Skewness $= E\left[\varepsilon^3\right] = E\left[\varepsilon \times \varepsilon^2\right] \leq 0$
  - High RV (ε^2) correlated with bad times
- Consistent with our RV results drive by downward part of RV

$$rv_t^{down} \equiv \sum_{days \in t} r_t^2 \times 1\left\{r_t < 0\right\}$$

Skewness in the data

- Skewness of growth rates:

	Monthly	Quarterly
Employment	-0.41	-0.41
Cap. Util.	-1.02	-1.30
Indus. Prod.	- 0.87	-0.87
Output		-0.32
Consumption		-0.33
Investment		-0.62

- Skewness of monthly S&P 500 returns:

Implied (since 1990):	-1.81
Realized (since 1990):	-0.61
Realized (since 1948):	-0.42

Model structure

- Output and capital:

$$
\begin{aligned}
Y_t &= A_t^{1-\alpha} K_t^{\alpha} N_t^{1-\alpha} \\
K_t &= (1-\delta) K_{t-1} + K_{t-1}^{agg} \left(\frac{I_t}{K_{t-1}^{agg}} - \frac{\zeta}{2} \left(\frac{I_t}{K_{t-1}^{agg}} - \overline{I/K} \right) \right)^2
\end{aligned}
$$

- Agents have EZ utility with period utility:

$$
\max_{C,N} \sum_{j=0}^{\infty} \beta^j \left(\log \left(C_{t+j} - bC_{t+j-1}^{agg} \right) - \theta \frac{N_{t+j}^{1+\gamma}}{1+\gamma} \right)
$$

Technology process

- Technology only exogenous process

$$\begin{aligned}
\Delta \log A_t &= \sigma_{t-1}\bar{\sigma}_\varepsilon \varepsilon_t - J\left(\nu_t - \bar{p}\right) + \mu \\
\log \sigma_t &= \phi_\sigma \log \sigma_{t-1} + \sigma_\sigma \eta_t + \kappa_{\sigma,\nu}\nu_t \\
\varepsilon_t, \eta_t &\sim N\left(0,1\right) \\
\nu_t &\sim Bernoulli\left(\bar{p}\right)
\end{aligned}$$

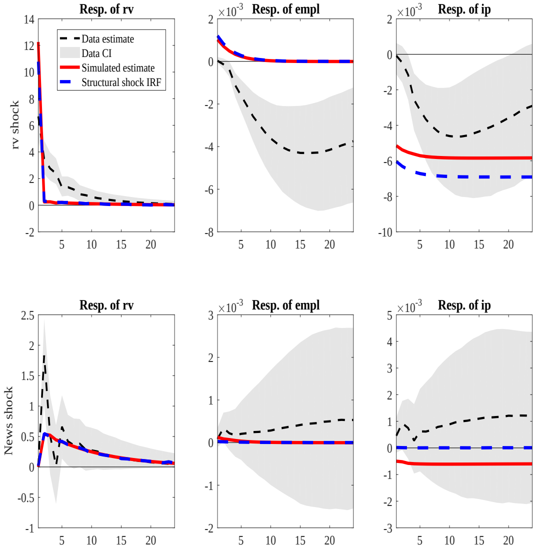
- ν is a jump shock of size J at freq $\bar{p}$
- η is pure uncertainty shock
- If $\kappa_{\sigma,\nu} < 0$ then countercyclical uncertainty

Calibration

Panel A: Moments	Model			Data		
	Mean	Std.	Skewness	Mean	Std.	Skewness
Returns	6.50	15.00	-4.92	7.46	14.77	-0.48
Output	1.99	2.02	-4.48	1.33	1.92	-0.11
Investment	1.99	3.64	-4.46	2.35	7.43	-0.03
Consumption	1.99	1.58	-3.41	1.20	1.06	-0.28

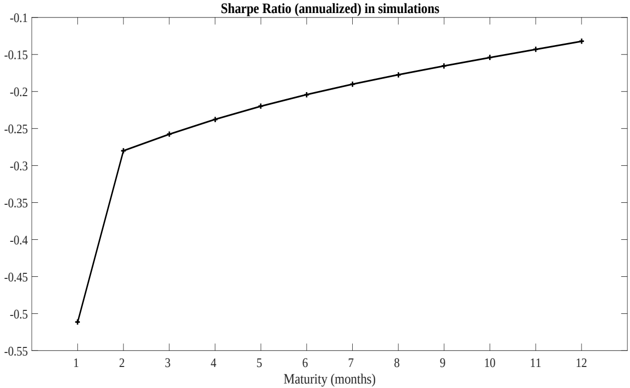
Panel B: Corr. of VAR and structural shocks		Structural shocks		
		Jv_t	η_t	ε_t
	RV	0.96	0.01	0.00
VAR identified shocks	Uncertainty	-0.01	0.91	-0.14

VAR results



Resp. of rv
Resp. of empl
Resp. of ip
rv shock
News shock
Data estimate
Data CI
Simulated estimate
Structural shock IRF
×10^-3

Asset pricing evidence



Summary

- Uncertainty shocks are second moment news – change in expected future volatility
- Key distinction: RV vs. uncertainty
  - RV associated with contractions, no evidence uncertainty is
  - Investors pay to hedge RV, not changes in uncertainty
- **Implication**: aggregate volatility matters, but through realization rather than forward-looking uncertainty
- Models should make similar distinction
  - Data broadly consistent with a model with negatively skewed TFP/demand shocks