Financial Origins of Uncertainty[1]

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June 2023, HKUST

[1]The views expressed herein are those of the authors and do not necessarily reflect the views of the Federal Reserve Bank of San Francisco or the Federal Reserve System.

Background

- Uncertainty rises in recession
  - Bloom et al.(2009, 2018), Leduc and Liu (2016) etc.
- Open question: uncertainty is
  - an exogenous source of business cycle fluctuations?
  - an endogenous response to economic fundamentals?
- Recent evidence: Ludvigson, Ma and Ng (2021) etc.
  - countercyclical macroeconomic uncertainty is often an endogenous response to fundamental shocks.
- This paper studies the sources of endogenous uncertainty
  - fundamental shocks $\rightarrow$? $\rightarrow$ endogenous uncertainty

Existing theories of endogenous uncertainty

- search and matching $\rightarrow$ endogenous uncertainty
  - Bernstein et al.(2021)
- nominal interest rate bound $\rightarrow$ endogenous uncertainty
  - Plante et al. (2018)
- asymmetric hiring rules $\rightarrow$ endogenous uncertainty
  - Ilut et al.(2018)
- fluctuations in real activity $\rightarrow$ information production $\rightarrow$ endogenous uncertainty
  - Fajgelbaum et al.(2017), Benhabib, Liu and Wang (2016,2019), Straub and Ulbricht (2023)

This paper

- Stylized fact:
  - uncertainty is negatively correlated with macro indicators on average
  - (new) ... more negative in periods with greater financial stress
- A theory of financial constraints and state-dependent uncertainty
  - fundamental shocks $\rightarrow$ credit friction $\rightarrow$ endogenous uncertainty
- Key mechanism: procyclical leverage
  - fundamental shocks $\downarrow \rightarrow$ LTV (not just V) $\downarrow \rightarrow$ amplification $\uparrow \rightarrow$ uncertainty (forecast error) $\uparrow$
- Consistent with observation:
  1. persistently depressed production
  2. large credit spreads
  3. a rise in default rates
  4. an increased cross-sectional dispersion of firm sales
  5. the contemporaneous increase in measured aggregate uncertainty

Data: Measuring real uncertainty

1. Define a measure for uncertainty about output growth (following Jurado et al. (2015) and Ludvigson et al. (2021))

$$U^{y}_{t,t+1} = \frac{1}{sd(\Delta y)} \sqrt{E_t \left\{ [\Delta y_{t+1} - E_t(\Delta y_{t+1})]^2 \right\}} \tag{1}$$

   where $y_t = log(Y_t)$ and $\Delta y_t = y_t - y_{t-1}$, and we normalize by the standard deviation of output growth (Δy) in the ergodic distribution.

2. Measure uncertainty about consumption, labor and credit in similar way

3. Construct a 'CORE' real uncertainty index as simple average of four individual uncertainty series.

Real Uncertainty Series

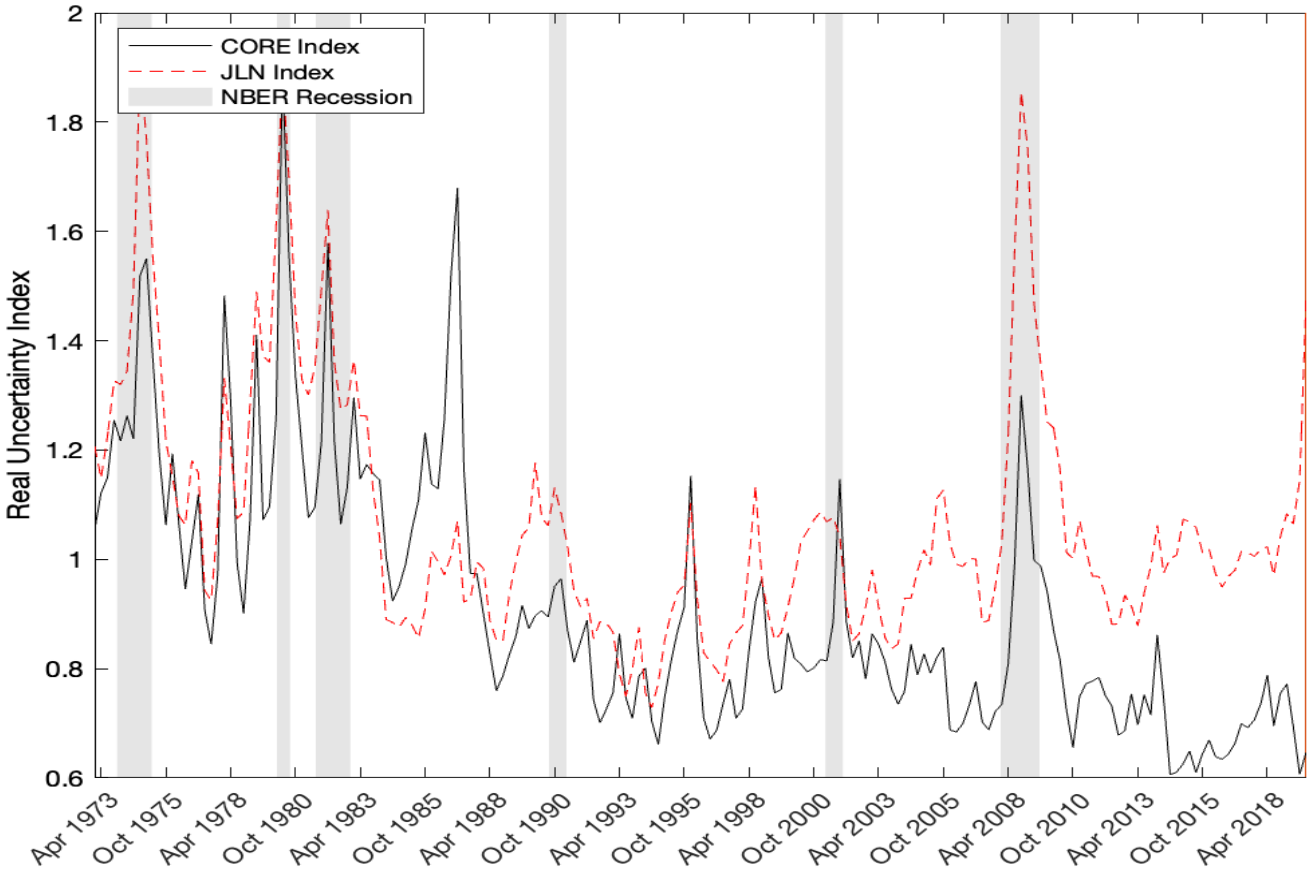

Figure: Real Uncertainty Series. Shaded grey bars are NBER recessions. ($corr(U^{y}_{t,t+1}, \Delta y_t) = -0.36$).

Role of Financial Factors

Table 1: Cyclicality of Uncertainty in Different Financial Regimes

	JLN	CORE	Output	Consum.	Hour	Credit
Average	-0.4847	-0.2359	-0.3280	-0.1568	-0.1043	-0.2733
Panel A: Financial Regime based on ANFCI						
Loose	-0.0254	0.0979	0.1480	-0.0191	0.2278	0.0529
Tight	-0.6725	-0.4199	-0.4731	-0.2172	-0.3012	-0.4134
Panel B: Financial Regime based on Financial Uncertainty Index						
Loose	-0.0742	0.1361	-0.1237	0.2039	0.1153	0.0043
Tight	-0.5422	-0.2827	-0.3416	-0.1704	-0.1767	-0.3091

- when financial condition is loose, real uncertainty is uncorrelated with growth measures;
- when financial uncertainty is tight, real uncertainty is (strongly) negatively correlated with economic growth (i.e. countercyclical).

Role of Financial Factors

Table 1A: Cyclicality of Uncertainty in Different Financial Regimes (robustness)

	JLN	CORE	Output	Consum.	Hour	Credit
Average	-0.4847	-0.2359	-0.3280	-0.1568	-0.1043	-0.2733
Panel A: Credit spread: Baa						
Low	-0.2944	-0.0997	-0.1533	-0.1404	0.0643	-0.0708
High	-0.5560	-0.3126	-0.4018	-0.1882	-0.2131	-0.3592
Panel B: Credit spread index: GZ						
Low	-0.3474	-0.2617	-0.3071	-0.2653	-0.0897	-0.1170
High	-0.6719	-0.3475	-0.5213	-0.1591	-0.3433	-0.3813
Panel C: Excess bond premium: GZ						
Low	-0.3452	-0.1502	-0.3015	-0.1125	-0.0514	-0.0610
High	-0.5205	-0.2137	-0.3173	-0.0821	-0.1318	-0.3331

Theory: Preview

- RBC model with hetero- firm and endogenous default risk
  - firm s.t. working capital constraint
  - productive firm constrained by default risk limit
- First-moment shock generates endogenous response in uncertainty
  - TFP/Credit shock $\rightarrow$ reallocation channel $\rightarrow$ endogenous TFP $\rightarrow$ endogenous uncertainty
  - TFP/Credit shock $\rightarrow$ default risk $\rightarrow$ financial stress $\rightarrow$ endogenous uncertainty
  - Uncertainty shock $\rightarrow$ reallocation channel $\rightarrow$ endogenous TFP $\rightarrow$ synchronized recession

Firms

- Timeline
  1. At the beginning of each period, aggregate productivity shocks (A_t) are realized.
  2. Firms choose the size of loan offered by risk-neutral, competitive creditors
  3. Firms observe the i.i.d. idiosyncratic productivity shock (ε_{jt}) and choose the optimal scale of production.
  4. After production, idiosyncratic liquidity shocks (ϕ_{jt}) are realized, and firms may choose to either repay the debt or to default and quit the market.
  5. Each exiting firm is replaced by a new entrant, after paying due operation cost. (aggregate liquidity cost in fixed)

Firms

Bellman equation

$$V_t(\varepsilon_{jt}, \phi_{jt}) = \max_{b_t, k_{jt}, n_{jt}} \underbrace{l_t}_{loan} - \underbrace{(W_t n_{jt} + R_t k_{jt})}_{cost} + \underbrace{A_t \varepsilon_{jt} k_{jt}^{\alpha} n_{jt}^{1-\alpha}}_{revenue}$$

$$+ \underbrace{\max\{0, E_t M_{t+1} V_{t+1} - b_t - \phi_{jt}\}}_{\text{continuation value}}$$

subject to a working capital constraint

$$W_t n_{jt} + R_t k_{jt} \leq \int_{\phi_{jt} \in \Phi^n} b_t dF(\phi) \equiv l_t$$

ϕ_{jt}: idiosyncratic operation cost shock (i.i.d.) with C.D.F $G(\phi)$;
Φ^n: set of non-default states.

Firms

- Cut-off in liquidity (ϕ_{jt}): above which firm defaults, given $\{b_t\}$

$$\phi_t^* = E_t M_{t+1} V_{t+1} - b_t \equiv q_t - b_t \tag{2}$$

(ε_{jt} is i.i.d. shock: the cut-off is not firm-specific.)

- Risk-neutral and competitive lenders lend and break-even

$$l_t = G(\phi_t^*) b_t$$

- Spread:

$$SPR_t = 1 - G(\phi_t^*)$$

- Cut-off in productivity (ϵ_{jt}): above which firm produces

$$\varepsilon_t^* = \frac{1}{A_t} \left(\frac{R_t}{\alpha}\right)^{\alpha} \left(\frac{W_t}{1-\alpha}\right)^{1-\alpha} \tag{3}$$

Firms

Value of a firm is

$$\bar{V}_t(A_t, \varepsilon_{jt}) = \begin{cases} (\frac{\varepsilon_{jt}}{\varepsilon_t^*} - 1)(1 - SPR_t)b_t + \int^{\phi_t^*} [\phi_t^* - \phi] dG(\phi), & \varepsilon_{jt} \geq \varepsilon_t^* \\ (1 - SPR_t)b_t + \int^{\phi_t^*} [\phi_t^* - \phi] dG(\phi), & (inaction) \end{cases} \quad (4)$$

Ex ante expected value of firms:

$$\tilde{V}(A_t) = \max_{b_t} \int_{\varepsilon_t^*} (\frac{\varepsilon_{jt}}{\varepsilon_t^*} - 1) dF(\varepsilon)(1 - SPR_t)b_t + \int^{\phi_t^*} (q_t - \phi) dG(\phi)$$

F.O.C. w.r.t b_t:

$$\int_{\varepsilon_t^*} (\frac{\varepsilon}{\varepsilon_t^*} - 1) dF(\varepsilon)(1 - SPR_t) = \left[\int_{\varepsilon_t^*} (\frac{\varepsilon}{\varepsilon_t^*} - 1) dF(\varepsilon) + 1 \right] g(\phi_t^*) b_t \quad (5)$$

(intuition: benefit and cost of raising additional debt are equalized)

Entrepreneurs

The representative entrepreneur

1. owns all the firms,

$$\mathbf{E} \sum_{t=0}^{\infty} \Phi_t (\beta^e)^t \log C_t^e \tag{6}$$

Φ_t: intertemporal preference shock.

2. does not accumulate capital,

$$C_t^e = D_t \tag{7}$$

where D_t is aggregate flow profit of firms

$$D_t = [\int_{\varepsilon_t^*} (\frac{\varepsilon}{\varepsilon_t^*} - 1) dF(\varepsilon)](1 - SPR_t) b_t \tag{8}$$

3. implied stochastic discount factor (SDF):

$$M_{t+1} = \varphi_{t+1} \beta^e \frac{D_t}{D_{t+1}}, \tag{9}$$

where $\varphi_{t+1} = \frac{\Phi_{t+1}}{\Phi_t}$: SDF shock

Household

Household's decision rules are characterized by the following equations:

$$\psi N_t^{\gamma} = \frac{1}{C_t^h} W_t \tag{10}$$

$$R_t = \delta_0 u_t^{\eta} \tag{11}$$

$$\begin{aligned} 1 = \quad & Q_t \left(1 - \frac{\Omega_k}{2}\left(\frac{I_t}{I_{t-1}} - 1\right)^2 - \Omega_k \left(\frac{I_t}{I_{t-1}} - 1\right)\frac{I_t}{I_{t-1}}\right) \\ & + \beta E_t \frac{C_t^h}{C_{t+1}^h} Q_{t+1} \Omega_k \left(\frac{I_{t+1}}{I_t} - 1\right)\left(\frac{I_{t+1}}{I_t}\right)^2 \end{aligned} \tag{12}$$

where Q_t is Tobin's q that measures return to capital and it satisfies

$$Q_t = \beta E_t \frac{C_t^h}{C_{t+1}^h} \left(R_{t+1} u_{t+1} + (1 - \delta_{t+1}) Q_{t+1}\right) \tag{13}$$

Market Clearing Conditions

1. Labor

$$W_t N_t = (1-\alpha)(1-SPR_t)b_t[1-F(\varepsilon_t^*)] \tag{14}$$

2. Capital

$$R_t u_t K_t = \alpha(1-SPR_t)b_t[1-F(\varepsilon_t^*)] \tag{15}$$

3. Output

$$Y_t = \int_{\varepsilon_t^*} \frac{\varepsilon}{\varepsilon_t^*} dF(\varepsilon)(1-SPR_t)b_t \tag{16}$$

4. Goods

$$Y_t = C_t^e + C_t^h + I_t + E_t(\phi_{jt}) \tag{17}$$

Calibration

	Parameter Description	Value	Target/ Reference
β	DF: Household	0.99	Risk-free interest rate
β^e	DF: Entrepreneur	0.98	Excess equity return
γ	Inverse Frisch elasticity	0	Hansen (1985)
ψ	Utility weight on leisure	3.00	Hours $= 1/3$ of time endowment
α	Capital share	0.35	Labor income share of 0.65
$\delta_0/(1+\eta)$	Steady state depreciation	0.025	Annual depreciation rate of 10%
η	Elas. of DP to utilization	0.40	Wen (1998); Liu and Wang (2014)
Ω_k	Inv. adjustment cost	0.71	Estimated
ν	Shape parameter of F()	5.7	Avg. economic profit
κ	Shape parameter of G()	2.8	Debt to quarterly GDP ratio
$\bar{\phi}/Y$	Fixed cost to output	0.12	Corporate Bond Spread
ρ_a	Persistence: TFP	0.95	Cooley (1995)
σ_a	Volatility: TFP	0.0075	Cooley (1995)
ρ_φ	Persistence: SDF	0.9741	Albuquerque (2016)
σ_φ	Volatility: SDF	0.0017	Albuquerque (2016)

Impact of TFP Shocks

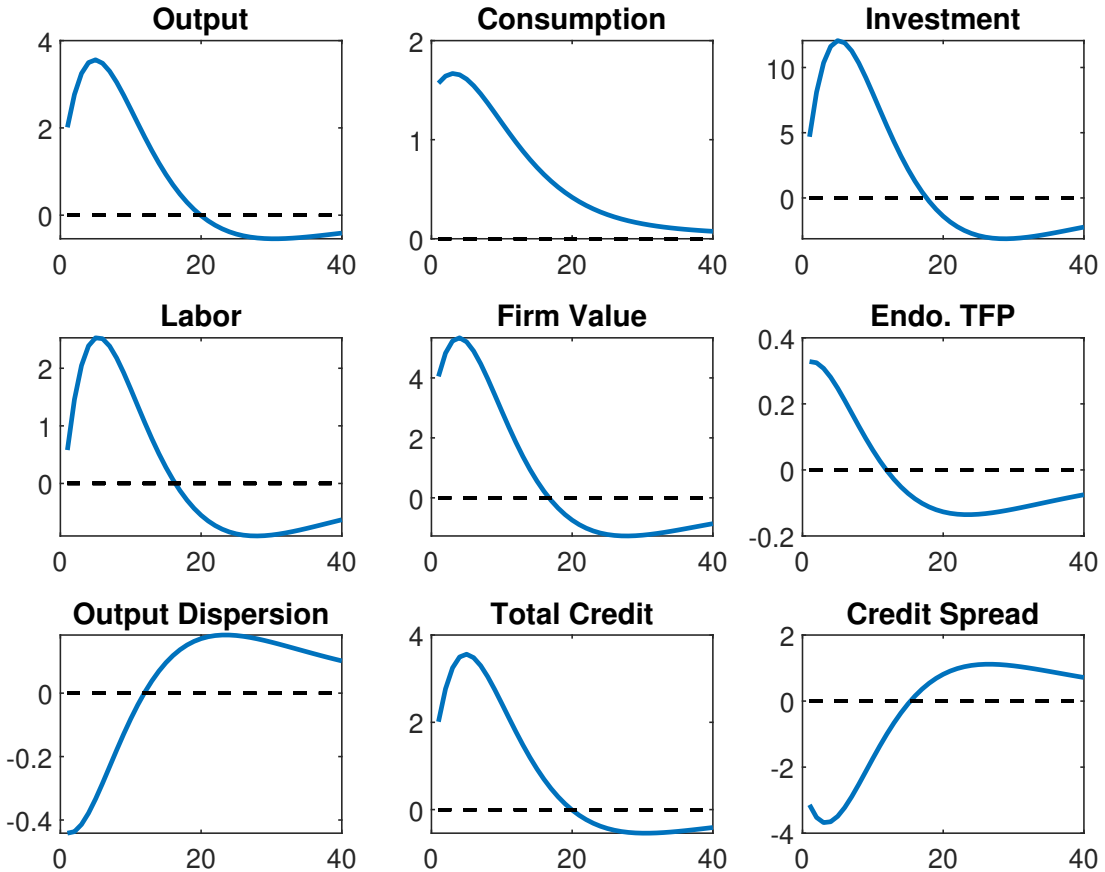

Figure: IRFs to TFP Shock

Impact of SDF Shocks

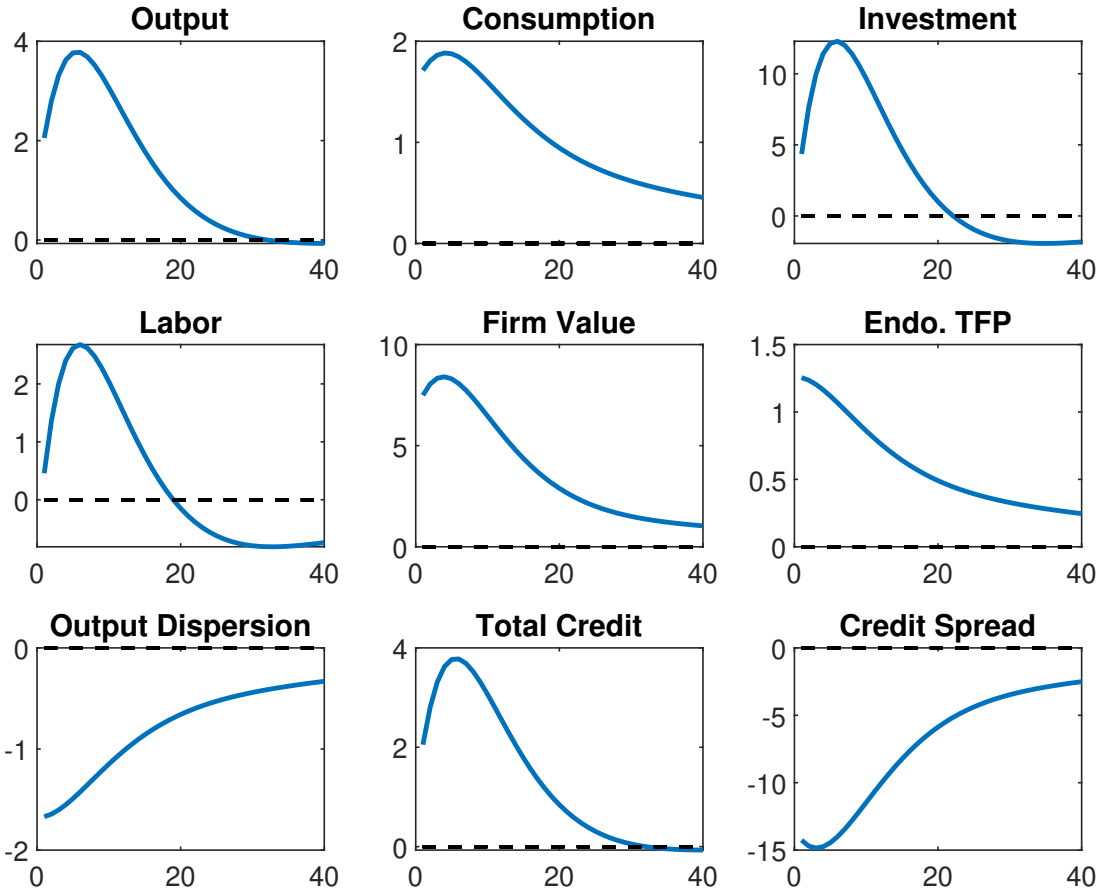

Figure: IRFs to SDF Shock

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State-dependent effects and procyclical leverage

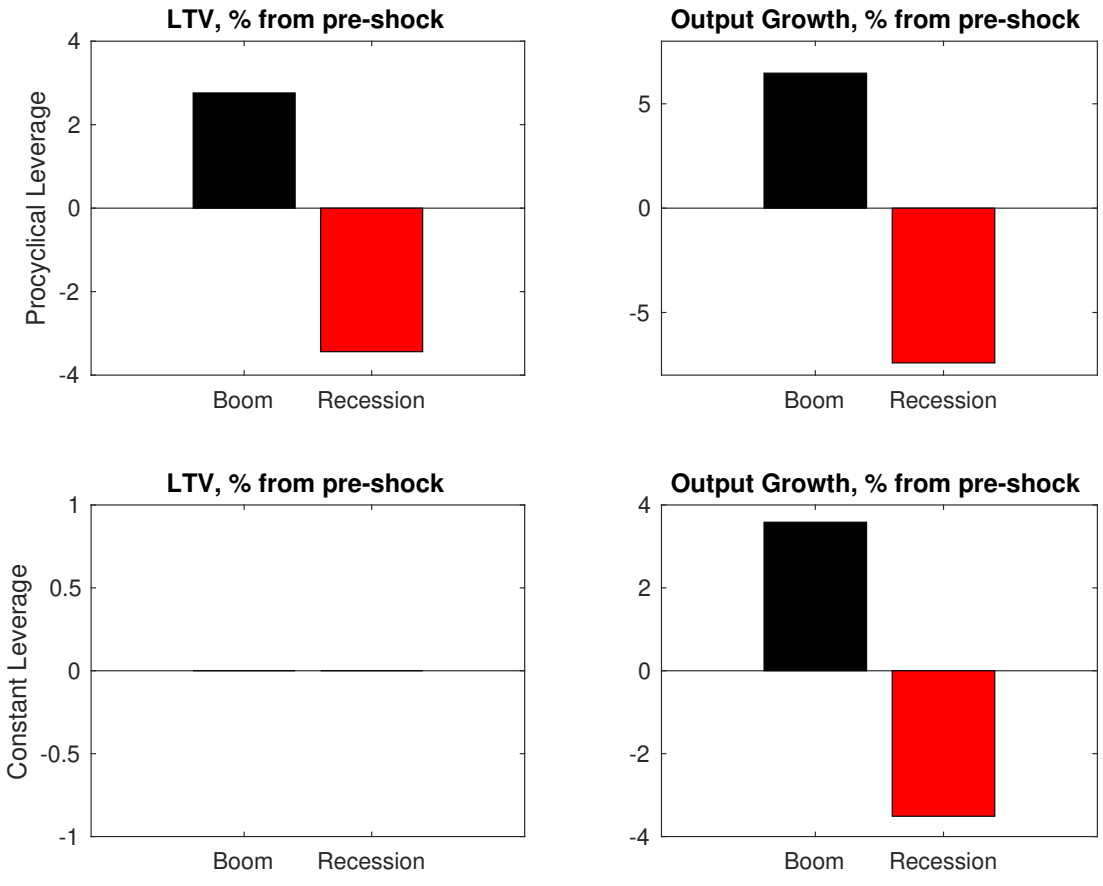

Figure: Pro-cyclical leverage and state-dependent effects

Endogenous Uncertainty

Table: Corr. b/w Output Growth and Endogenous Uncertainty (Simulation)

	$U^{CORE}_{t,t+1}$	$U^{y}_{t,t+1}$	$U^{c}_{t,t+1}$	$U^{n}_{t,t+1}$	$U^{b}_{t,t+1}$
Benchmark	-0.3234	-0.3152	-0.1993	-0.4638	-0.3152
		(0.0385)	(0.0410)	(0.0371)	(0.0385)
Counterfactual: Loose financial condition with lower $\bar{\phi}$					
Loose	-0.2077	-0.1566	-0.0831	-0.4344	-0.1566
		(0.0385)	(0.0386)	(0.0341)	(0.0385)

- Counterfactual economy: lower $\bar{\phi}$ (half of calibrated value)
  - Steady-state credit spread is lower (i.e. less financial friction)

Financial Uncertainty Shock

- Ludvigson et al.(2021): financial uncertainty shocks are driving force of declines in real activity.
  - financial uncertainty shocks: 'second moment' variable that could arise because of expected volatility in financial markets such as fear of bankruptcy
- Our model is consistent with such observation by showing the effects of a second moment shock on liquidity risk.
  - assume that κ is time-varying and follows an AR(1) process in log:

$$\log(\kappa_t) = (1-\rho_f)\log(\kappa) + \rho_f \log(\kappa_{t-1}) + \sigma_f \varepsilon_t^F, \quad \varepsilon_t^f \sim N(0,1) \tag{18}$$

Financial Uncertainty Shock

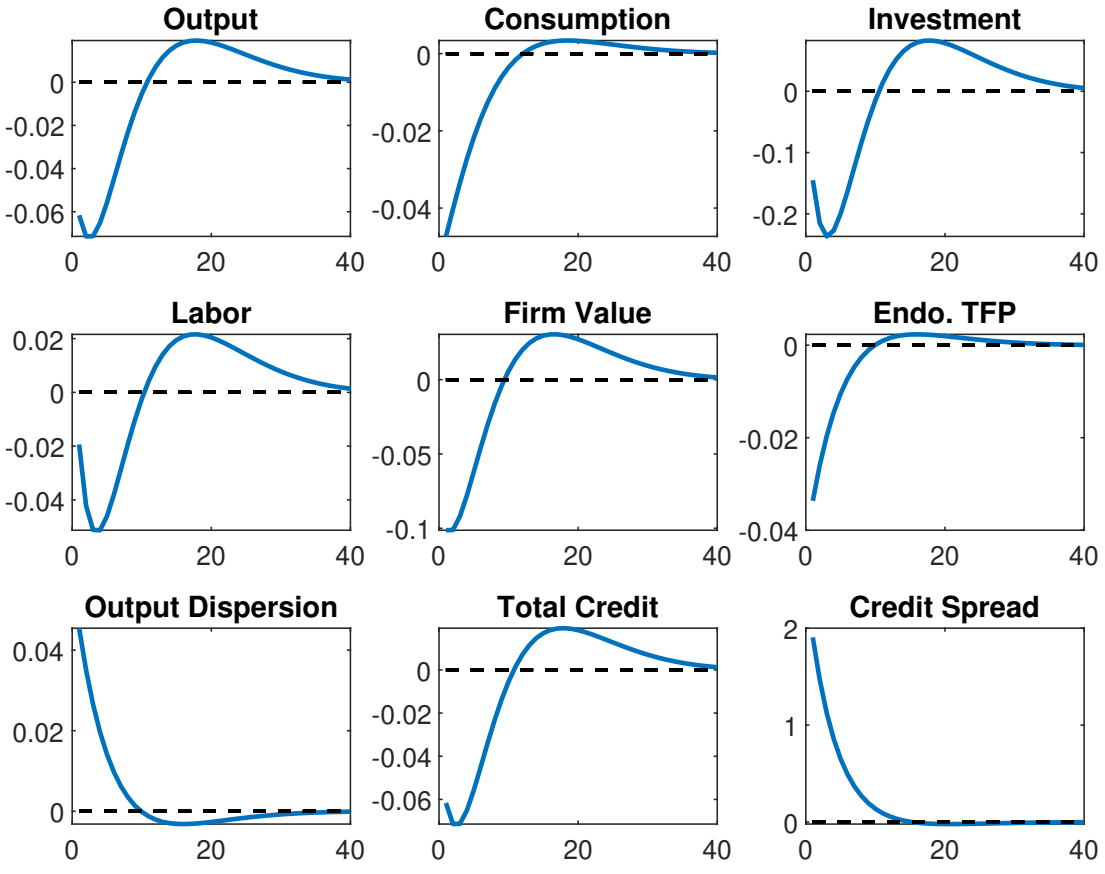

Figure: IRFs to Financial Uncertainty Shock

Conclusion

1. Financial frictions give rise to countercyclical uncertainty.
2. In a RBC model with heterogeneous firms,
   - Default risks limit the access of productive firms to external credit.
   - Negative first-moment shock reduces firms' borrowing capacity and production disproportionately more than a positive shock
   - Asymmetric (or state-dependent) responses of aggregate variables imply a larger conditional variance of forecast errors (i.e. countercyclical uncertainty)
3. Uncertainty is less negatively correlated with aggregate output growth in periods with less financial stress.
4. Financial uncertainty shock generates synchronized recession
   - Key: reallocation channel stemming from financial frictions.