

The Macroeconomics of Shadow Banking

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Shadow banking, what is it good for?

Three views:

1. Regulatory arbitrage
 - avoid capital requirements, exploit implicit guarantees
2. Neglected risks
 - package risky investments as safe, pass on to unsuspecting investors
3. Liquidity transformation
 - create money-like liquid instruments from a broader set of assets

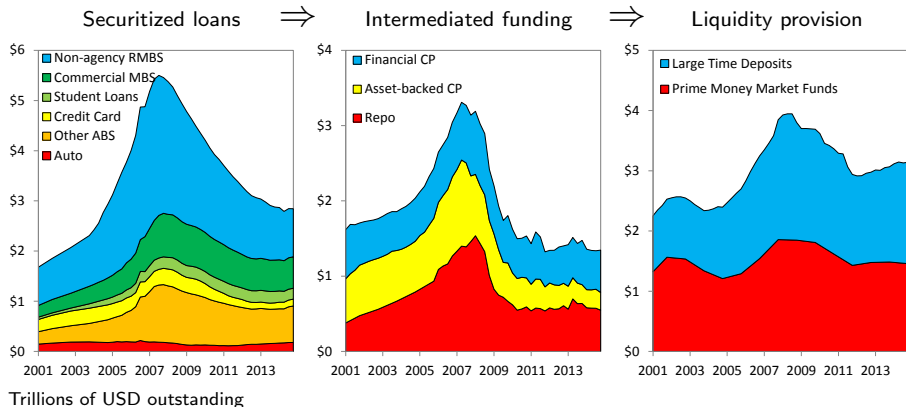
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All reform proposals take an implicit stance

The liquidity transformation view of shadow banking



1. Shadow banking turns risky assets into liquid liabilities
 \Rightarrow expands credit to the economy and liquidity provision to households/institutions
2. Bigger booms, deeper busts
 \Rightarrow tradeoff between growth and fragility

Our framework

1. Investors demand liquid securities to consume in high marginal-utility states (liquidity events)
 - liquidity \Leftrightarrow low shock exposure \Leftrightarrow overcollateralization
2. Intermediaries invest in assets and finance with
 - **money** safe \Rightarrow always liquid (e.g. government money market fund)
 - equity residual \Rightarrow illiquid (e.g. “toxic waste” CDO tranche)
 - **shadow money** safe except in a crash \Rightarrow liquid except in a crash (e.g. Financial CP, ABCP, private-label repo, etc.)

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3. Collateral constrains liquidity provision:

$$\text{Money} \times 1 + \text{Shadow money} \times \left(1 - \frac{\text{Crash loss}}{\text{Value of assets in a crash}} \right) \leq \text{Value of assets in a crash}$$

- tradeoff between quantity and fragility of the liquidity supply
4. Uncertainty drives demand for fragile vs. crash-proof liquidity

MODEL ROADMAP

1. **Static model for core mechanism, analytical expressions**
2. Dynamic model for amplification, cycles, and effects of policy

Static model: preferences, endowment, and information

1. Three dates, 0 , 1 and 2. Investors subject to liquidity events

$$U_0 = \max E_0 [z_1 C_1 + C_2]$$

- $z_1 \in \{1, \psi\}$, where $z_1 = \psi$ privately-observed liquidity event
- $z_1 = \psi$ with probability h , i.i.d. across investors

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3. Promises require collateral. Endowed with asset that pays

$$Y_2 = \begin{cases} 1 + \mu_Y, & \text{prob. } 1 - \lambda_0 \quad (\text{normal times}) \\ 1 - \kappa_Y, & \text{prob. } \lambda_0 \quad (\text{crash}) \end{cases}$$

- normalize $E_0[Y_2] = 1$, λ_0 measures uncertainty
- normalize $q_0 = 1$, assets are the numeraire

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3. Information

- Date 1 public signal reveals updated crash prob., $\lambda_1 \in \{\lambda^L, \lambda^H\}$
- Date 1 private signal costs f and reveals asset payoff Y_2

Securities and liquidity

Assumption (Liquidity)

Investors in a liquidity event trade only claims that they can sell for their present value under public information. We call these liquid claims.

1. Intermediaries buy assets at date 0 and tranche into securities
 - security x with yield μ_x , **crash exposure** κ_x :

$$r_2^x = \begin{cases} 1 + \mu_x, & \text{if } Y_2 = 1 + \mu_Y \quad (\text{normal times}) \\ 1 - \kappa_x, & \text{if } Y_2 = 1 - \kappa_Y \quad (\text{crash}) \end{cases}$$

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2. Implications of Assumption 1

- Liquid security needs sufficiently low κ_x to deter info. production
- Security liquid when $\lambda_1 = \lambda^L$ might not be when $\lambda_1 = \lambda^H$

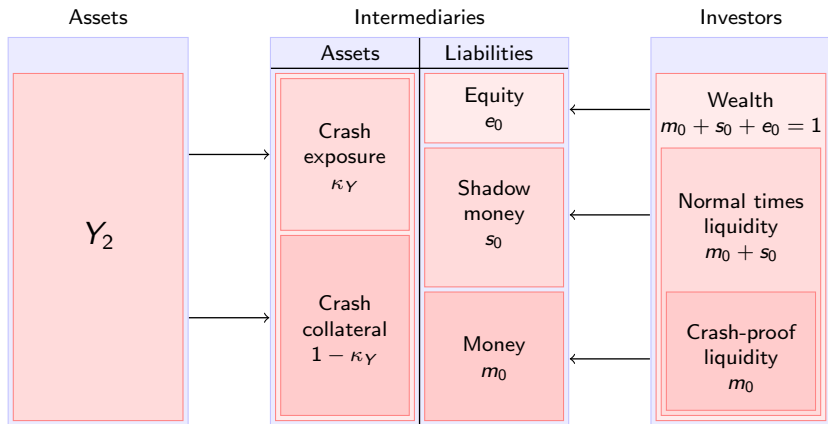
Proposition (Securities)

Intermediaries optimally issue the following three securities:

- i. money m with $\kappa_m = 0$ is liquid for $\lambda_1 \in \{\lambda^L, \lambda^H\}$ (always-liquid);
- ii. shadow money s with $\kappa_s = \bar{\kappa}$ is liquid if $\lambda_1 = \lambda^L$ (fragile-liquid);
- iii. equity e with $\kappa_e = 1$ is illiquid,

where $0 < \bar{\kappa} < 1$ under appropriate parameter restrictions.

Balance sheet view



Equilibrium

Equilibrium allocation solves

$$\max_{m_0, s_0 \geq 0} E_0 \left[h(\psi - 1) C_1 + Y_2 \right] \quad (1)$$

subject to $m_0 + s_0 \leq 1$, the liquidity constraint

$$C_1 \leq \begin{cases} m_0 + s_0 & \text{if } \lambda_1 = \lambda^L, \text{ prob. } 1 - p_H(\lambda_0) \\ m_0 & \text{if } \lambda_1 = \lambda^H, \text{ prob. } p_H(\lambda_0), \end{cases} \quad (2)$$

and the collateral constraint

$$m_0 + s_0 (1 - \bar{\kappa}) \leq 1 - \kappa_Y. \quad (3)$$

Investors weigh

- the liquidity advantage of money $p_H(\lambda_0)$ against
- the collateral advantage of shadow money $\bar{\kappa}$

Equilibrium

Proposition (Equilibrium security issuance)

Suppose that $\bar{\kappa} \leq \kappa_Y$. Then in equilibrium money and shadow money issuance, m_0 and s_0 , is as follows:

- i. if $p_H(\lambda_0) \leq \bar{\kappa}$, then $m_0 = 0$ and $s_0 = \frac{1 - \kappa_Y}{1 - \bar{\kappa}}$;
- ii. if $p_H(\lambda_0) > \bar{\kappa}$, then $m_0 = 1 - \kappa_Y$ and $s_0 = 0$.

Trade-off between quantity and stability of the liquidity supply

- Low uncertainty, shadow money crowds out money
(supply large but fragile)
- High uncertainty, only money issued
(supply small but stable)

MODEL ROADMAP

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Capital accumulation

1. Two technologies: A high-growth risky; B low-growth safe

$$dk_t^a/k_t^a = [\phi^a(\iota_t^a) - \delta] dt - \kappa^a dZ_t$$

$$dk_t^b/k_t^b = [\phi^b(\iota_t^b) - \delta] dt$$

- investment ι_t^a, ι_t^b ; adjustment cost $\phi'' < 0$; depreciation δ
- $dZ_t \sim$ compensated (mean-zero) Poisson “crash”, exposure $\kappa^a > 0$
- intensity λ_t , measures uncertainty

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2. Output $y_t = y^a k_t^a + y^b k_t^b$

- productivity $y^a > y^b$
- capital mix becomes slow-moving state variable

$$\chi_t = \frac{k_t^a}{k_t^a + k_t^b}$$

Time-varying uncertainty

1. Latent true probability of a crash $\tilde{\lambda}_t \in \{\lambda^L, \lambda^H\}$
 - follows two-state Markov chain with generator unconditional mean $\bar{\lambda}$ and overall transition rate φ
 - agents learn from crashes (dZ_t) and Brownian “news” (dB_t)

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 - follows two-state Markov chain with generator unconditional mean $\bar{\lambda}$ and overall transition rate φ
 - agents learn from crashes (dZ_t) and Brownian “news” (dB_t)
2. Bayesian learning \Rightarrow time-varying uncertainty $\lambda_t = E_t[\tilde{\lambda}_t]$
 - low after a long quiet period (Great Moderation)
 - high after a crash (Reinhart-Rogoff)
 - jumps most from moderately low levels (“Minsky moment”)

$$d\lambda_t = \varphi (\bar{\lambda} - \lambda_t) dt + \Sigma_t \left(\nu dB_t + \frac{1}{\lambda_t} dZ_t \right), \quad (4)$$

where $\Sigma_t \equiv (\lambda^H - \lambda_t) (\lambda_t - \lambda^L) = \text{Var}_t(\tilde{\lambda}_t)$
and ν is the precision of the Brownian signal

Intermediaries and Markets

1. Intermediaries buy assets, set investment, and issue securities to maximize the present value of future profits

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3. Intermediaries tranche assets into securities. With two shocks (dZ_t, dB_t) , a generic security x 's return has the form

$$dr_t^x = \mu_{x,t} dt + \sigma_{x,t} dB_t - \kappa_{x,t} dZ_t. \quad (5)$$

Now we take the securities and liquidity profiles from before as given

- i. money m with $\kappa_{m,t} = \sigma_{m,t} = 0$ is liquid with probability 1 (always-liquid);
- ii. shadow money s with $\kappa_{s,t} = \bar{\kappa}$ and $\sigma_{s,t} = 0$ is liquid with probability $1 - p_H(\lambda_t)$, where $p_H'(\lambda_t) > 0$ (fragile-liquid);
- iii. equity e with $\kappa_{e,t} = 1$ and $|\sigma_{e,t}| > 0$ is illiquid.

Demand for liquidity and securities expected returns

$$\rho V_t dt = \max_{m_t, s_t, dc_t^\psi, c_t} E_t \left[W_t \left(\psi dc_t^\psi dz_t + c_t dt \right) \right] + E_t [dV_t] \quad (6)$$

subject to $c_t^\psi \leq \bar{c}_t^\psi$ and the budget and liquidity constraints

$$\frac{dW_t}{W_t} = dr_t^e + m_t(dr_t^m - dr_t^e) + s_t(dr_t^s - dr_t^e) - c_t dt - dc_t^\psi dz_t$$

$$dc_t^\psi \leq \begin{cases} m_t + s_t & \text{prob. } 1 - p_H(\lambda_t) \\ m_t & \text{prob. } p_H(\lambda_t). \end{cases}$$

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Risk-neutrality implies the problem simplifies to

$$\begin{aligned} \rho = \max_{m_t, s_t} & h(\psi - 1) \left[[1 - p_H(\lambda_t)] \int_0^\infty \min\{\bar{c}_t^\psi, m_t + s_t\} dF(\bar{c}_t^\psi) \right. \\ & \left. + p_H(\lambda_t) \int_0^\infty \min\{\bar{c}_t^\psi, m_t\} dF(\bar{c}_t^\psi) \right] + \mu_{W,t}. \end{aligned} \quad (7)$$

where $F(\bar{c}_t^\psi) = \text{Exp}(\eta)$

Demand for liquidity and securities expected returns

Proposition (Security expected returns)

The expected returns of money ($\mu_{m,t}$), shadow money ($\mu_{s,t}$), and equity ($\mu_{e,t}$) satisfy

$$\mu_{e,t} - \mu_{m,t} = h(\psi - 1) \left([1 - p_H(\lambda_t)] e^{-\eta(m_t + s_t)} + p_H(\lambda_t) e^{-\eta m_t} \right)$$

$$\mu_{s,t} - \mu_{m,t} = h(\psi - 1) p_H(\lambda_t) e^{-\eta m_t}.$$

The aggregate discount rate ($\mu_{W,t}$) satisfies

$$\mu_{W,t} = \left[\rho - \frac{h}{\eta} (\psi - 1) \right] + \frac{1}{\eta} (\mu_{e,t} - \mu_{m,t}).$$

A lower liquidity premium reduces the cost of consuming in a high marginal utility state, increasing savings.

Intermediaries

$$0 = \max_{m,s,k^a,k^b,\iota^a,\iota^b} [(y^a - \iota^a) k^a + (y^b - \iota^b) k^b] dt + E_t [dA_t] \\ + A_t [m(\mu_{e,t} - \mu_{m,t}) + s(\mu_{e,t} - \mu_{s,t}) - \mu_{e,t}] + E_t [dV_t],$$

subject to the collateral constraint

$$m_t + s_t(1 - \bar{\kappa}) \leq 1 - \kappa_{A,t}, [\theta_t] \quad (8)$$

Intermediaries

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subject to the collateral constraint

$$m_t + s_t(1 - \bar{\kappa}) \leq 1 - \kappa_{A,t}, [\theta_t] \quad (8)$$

where the aggregate collateral value is the value weighted sum of asset collateral values

$$1 - \kappa_{A,t} = \chi_t^q (1 - \kappa_k^a) (1 - \kappa_{q,t}^a) + (1 - \chi_t^q) (1 - \kappa_{q,t}^b), \quad (9)$$

- collateral values depend on the endogenous **price exposure**.
- θ low when asset B supply is high or shadow-money money spread $\mu_{s,t} - \mu_{m,t}$ is high
- $1 - \kappa_{q,t}^b \leq 1$ safe asset becomes risk because changes in the collateral premium θ_t

Intermediaries and the supply of liquidity

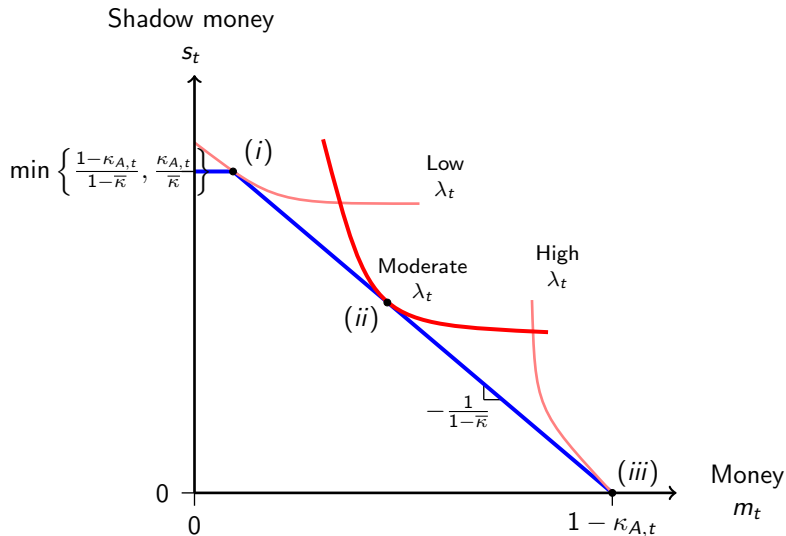
Proposition (Equilibrium security issuance)

Let $\mathcal{M}_t \equiv \frac{1}{\eta} \log \left(\frac{\bar{\kappa}}{1-\bar{\kappa}} \frac{1-p_H(\lambda_t)}{p_H(\lambda_t)} \right)$. Then in equilibrium issuance follows

- i. if $\mathcal{M}_t > \min \left\{ \frac{\kappa_{A,t}}{\bar{\kappa}}, \frac{1-\kappa_{A,t}}{1-\bar{\kappa}} \right\}$,
$$m_t = \max \left\{ 0, 1 - \frac{\kappa_{A,t}}{\bar{\kappa}} \right\} \text{ and } s_t = \min \left\{ \frac{1-\kappa_{A,t}}{1-\bar{\kappa}}, \frac{\kappa_{A,t}}{\bar{\kappa}} \right\};$$
- ii. if $0 \leq \mathcal{M}_t \leq \min \left\{ \frac{\kappa_{A,t}}{\bar{\kappa}}, \frac{1-\kappa_{A,t}}{1-\bar{\kappa}} \right\}$,
$$m_t = 1 - \kappa_{A,t} - (1 - \bar{\kappa}) \mathcal{M}_t \text{ and } s_t = \mathcal{M}_t; \text{ and}$$
- iii. if $\mathcal{M}_t < 0$, $m_t = 1 - \kappa_{A,t}$ and $s_t = 0$.

\mathcal{M}_t measures marginal value of first unit of shadow money

Intermediaries and the supply of liquidity



Intermediaries: asset prices and investment

1. Intermediaries can scale up their balance sheets by issuing more securities and buying more assets. We get a PDE:

$$q_t^i = \frac{y^i - l_t^i}{\left(\mu_{W,t} - \theta_t [(1 - \kappa_t^i) - (1 - \kappa_{A,t})] \right) - [\mu_{q,t}^i + \kappa_k^i \kappa_{q,t}^i \lambda_t + \phi(l_t^i) - \delta]}$$

- term in brackets is the asset expected return: assets with higher collateral value discounted at a lower rate
- When collateral becomes scarce (high θ), assets with high collateral value experience flight to quality

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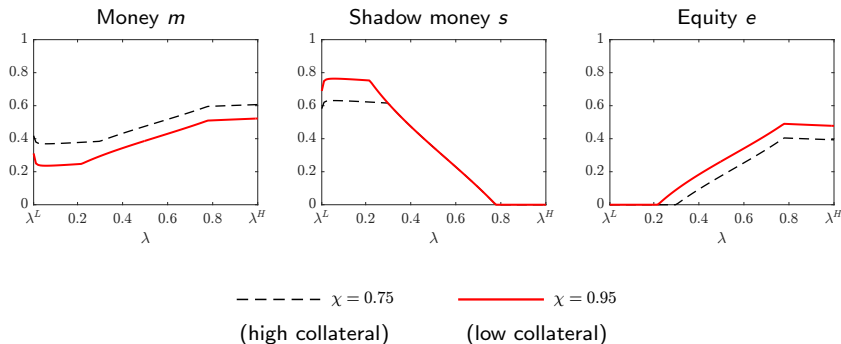
2. Intermediaries set investment, driven by standard q -theory:

$$1 = q_t^i \phi'(\iota_t^i), \quad i = a, b.$$

RESULTS

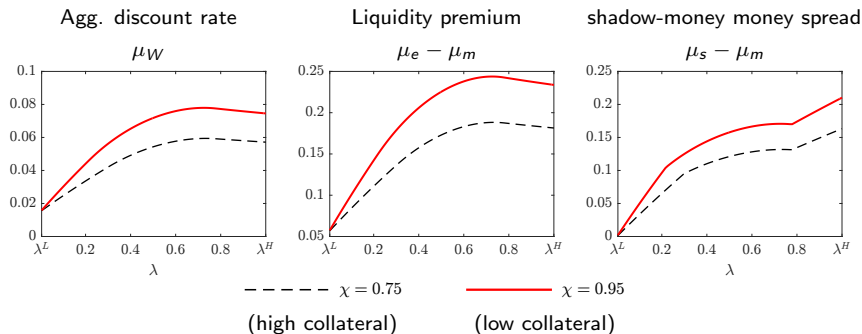
1. Parameter values in paper
2. Model in closed form up to prices
3. Solve for prices $q^i(\chi, \lambda)$, $i = a, b$ numerically using projection methods

Security markets



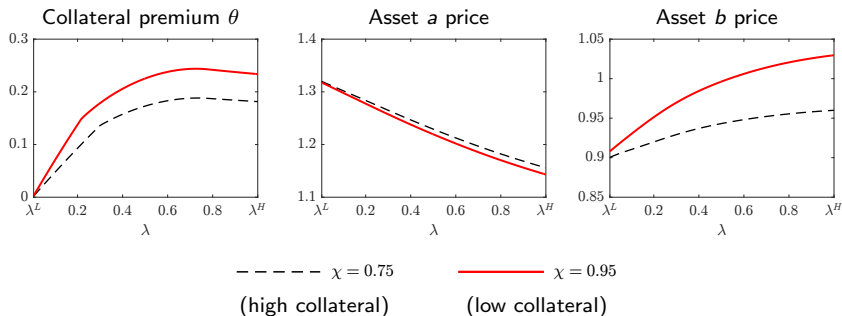
1. Shadow banking booms in low uncertainty-low collateral states
 - crowds out money creation in booms
 - disappears when uncertainty rises from a low level (e.g. August 07)
2. Money is produced most when collateral is abundant (low χ).

Discount rates



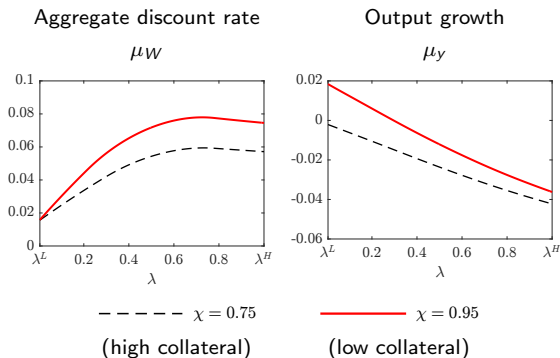
1. Higher uncertainty causes the shadow-money money spread to rise, shadow banking contracts, lower liquidity supply causes liquidity premium and overall discount rate to rise
2. Discount rates are more uncertainty-sensitive when shadow banking activity is high (low uncertainty, low collateral)

Asset markets



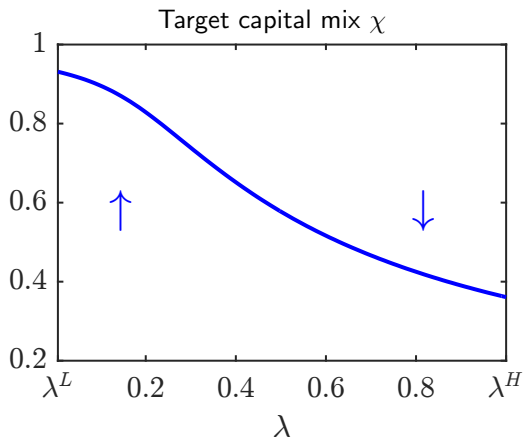
1. Higher uncertainty causes the collateral premium to rise, lowers the price of the risky asset and raises the price of the safe asset
2. Riskier asset mix χ means less collateral, lowers q^a and raises q^b

The macroeconomy



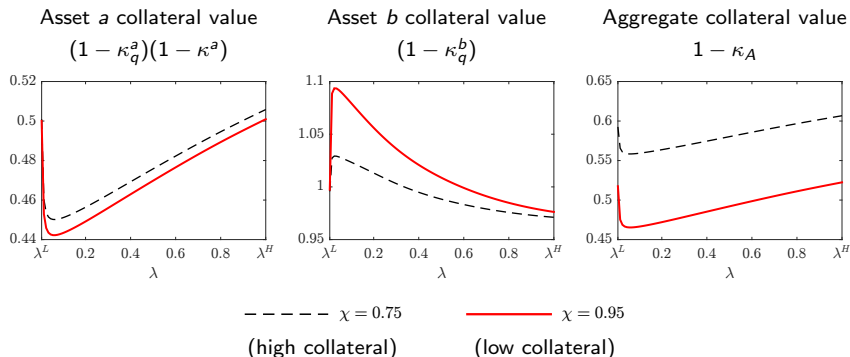
1. Growth more uncertainty-sensitive when shadow banking is high (collateral and uncertainty are low)
2. Real boom coincides with shadow banking boom

The macro cycle



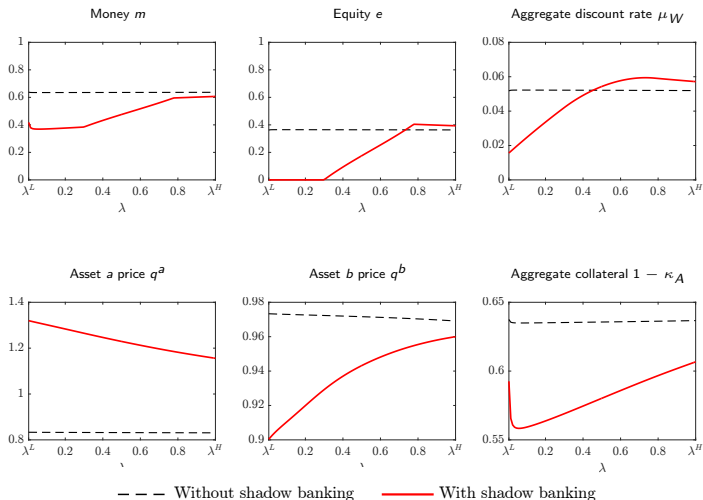
1. Capital mix drifts towards risky asset during shadow banking boom
 2. Capital mix drifts towards safe asset during bust
- ⇒ Fragility buildup in booms, collateral mining in bust

Collateral runs



1. Collateral values fall as prices fall \Rightarrow prices fall more, etc.
2. Amplifies liquidity contraction
3. Flight to quality implies safe assets have excess collateral

Cycles are a product of shadow banking

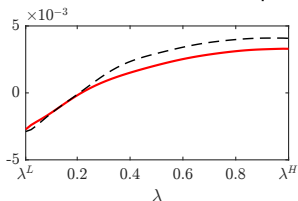


EFFECTS OF POLICY INTERVENTIONS

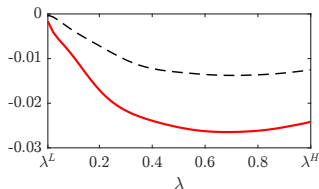
QE1 - Large-Scale Asset Purchases

1. Fed buys risky a and sells safe b asset (Ricardian)

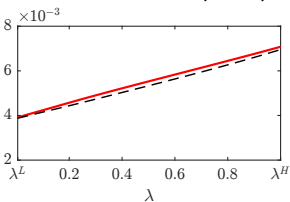
Announcement effect on a price



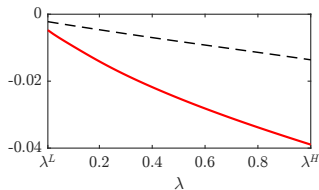
Announcement effect on b price



Ex ante effect on a price q^a



Ex ante effect on b price q^b



--- $\chi = 0.75$

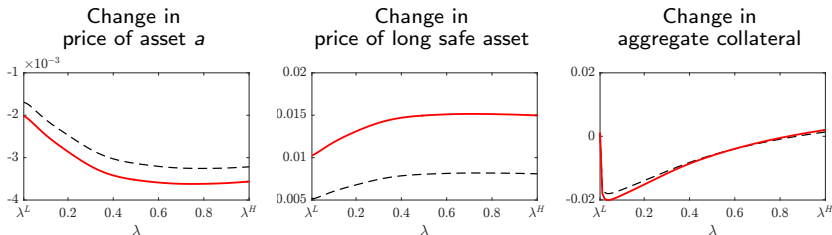
(high collateral)

— $\chi = 0.95$

(low collateral)

QE2 - Operation Twist

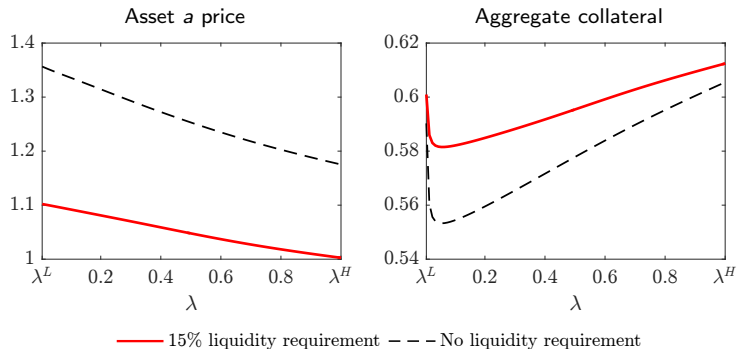
1. Fed buys long-term safe bonds and sells short-term safe bonds.
 - long-term safe bond acts as crash hedge due to flight to quality
 - short-term safe bond safe but not a hedge



2. OT reduces the supply of collateral \Rightarrow liquidity provision falls
 \Rightarrow discount rates rise, especially for risky/productive assets

Liquidity requirements

1. Limit liquidity mismatch: $m_t + s_t \leq \bar{l}$



3. Mitigate collateral runs, enhance financial stability
4. *But* higher discount rates, lower prices

Monetary policy normalization

1. Pre-crisis view: short-term rate captures monetary policy stance
2. Our framework:

$$Tbill\ rate = \left(\begin{array}{c} aggregate \\ discount\ rate \end{array} \right) - \theta_t \left(\begin{array}{c} collateral\ value \\ of\ Tbill \end{array} \right)$$

⇒ Tbill rate can be low if collateral premium θ_t is high and policy *tight*

3. Reverse repo facility
 - "... should help to establish a floor on the level of overnight rates."
(Dudley, 2013)
 - accommodative, even though pushes the safe rate up
 - releases collateral to financial system ($\theta_t \searrow$)

Takeaways

1. Liquidity transformation and the macro cycle
 - tradeoff between quantity and fragility of liquidity provision
2. Shadow banking expands liquidity supply in booms
 - lower discount rates, more investment, more growth
 - increases economic and financial fragility
3. Framework has implications for
 - monetary policy, financial stability regulation

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 - monetary policy, financial stability regulation

Is it better to have been liquid and lost than never to have been liquid at all?

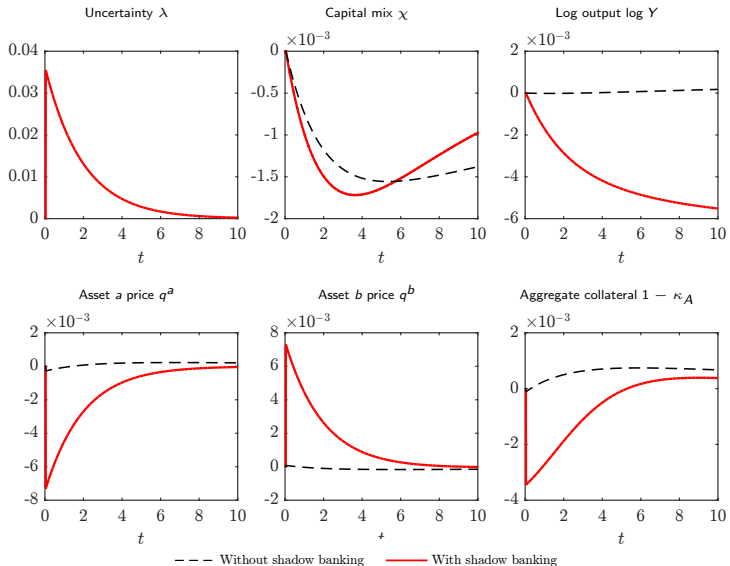
APPENDIX

Benchmark parameters

This table contains the benchmark values for the model parameters used to produce results for the dynamic model. The investment cost function is parameterized as $\phi(\iota) = 1/\gamma(\sqrt{1+2\gamma\iota} - 1)$. We use the specification implied by the static model for the probability that shadow money becomes illiquid. i.e. $p_H(\lambda) = (\lambda - \lambda^L) / (\lambda^H - \lambda^L)$.

Description	Parameter	Value
<i>Technology:</i>		
Asset cash flows	y^a, y^b	0.138, 0.1
Depreciation rate	δ	0.1
Exogenous aggregate growth	μ_0	0.01
Adjustment cost parameter	γ	3
Asset crash exposures	κ^a, κ^b	0.5, 0
<i>Information sensitivity constraint:</i>		
Crash exposure limit for fragile liquid securities	$\bar{\kappa}$	0.7
<i>Uncertainty:</i>		
Low/high uncertainty states	λ^L, λ^H	0.005, 1
Average uncertainty	$\bar{\lambda}$	0.0245
Uncertainty rate of mean reversion	φ	0.5
Uncertainty news signal precision	$1/\sigma$	0.1
<i>Preferences and liquidity events:</i>		
Liquidity event frequency	h	0.28
Liquidity event marginal utility	ψ	5
Average size of liquidity event	$1/\eta$	0.33
Subjective discounting parameter	ρ	0.37

Uncertainty shock impulse responses



Crash shock impulse responses

