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

All reform proposals take an implicit stance
The liquidity transformation view of shadow banking

1. Shadow banking turns risky assets into liquid liabilities
   ⇒ expands credit to the economy and liquidity provision to households/institutions

2. Bigger booms, deeper busts
   ⇒ tradeoff between growth and fragility

Moreira and Savov (2015)
Our framework

1. Investors demand liquid securities to consume in high marginal-utility states (liquidity events)
   - liquidity ⇔ no adverse selection ⇔ overcollateralization

2. Intermediaries invest in assets and finance with
   - **money** safe ⇒ always liquid (e.g. government money market fund)
   - equity residual ⇒ illiquid (e.g. “toxic waste” CDO tranche)
   - **shadow money** safe except in a crash ⇒ liquid most of the time
     (e.g. Financial CP, ABCP, private-label repo, etc.)

3. Collateral constrains liquidity provision:

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

- tradeoff between quantity and stability of the liquidity supply

4. Uncertainty drives demand for fragile vs. stable liquidity

Moreira and Savov (2015)
Related literature

1. **Banking**: Diamond and Dybvig (1983); Gorton and Pennacchi (1990); Allen and Gale (1998); Gorton and Ordoñez (2012); Dang, Gorton, and Holmström (2010); Gennaioli, Shleifer, and Vishny (2013); Hanson, Shleifer, Stein, Vishny (2014)

2. **Macro-finance**: Bernanke and Gertler (1989); Bernanke, Gertler, and Gilchrist (1999); Kiyotaki and Moore (1997); Adrian and Shin (2010); Garleanu and Pedersen (2011); He and Krishnamurthy (2013); Brunnermeier and Sannikov (2014); Adrian and Boyarchenko (2012); Geanakoplos (2003); Gertler and Kiyotaki (2010, 2013); Sannikov (2014); Maggiori (2013); Kurlat (2012); Bigio (2013)

3. **Demand for safety/liquidity**: Holmström and Tirole (1998); Kiyotaki and Moore (2012); Brunnermeier and Sannikov (2011); Greenwood, Hanson, and Stein (2012); Krishnamurthy and Vissing-Jorgensen (2012); Caballero and Farhi (2013)

4. **Funding liquidity and collateral runs**: Brunnermeier and Pedersen (2009); Gorton and Metrick (2011)

5. **Unconventional monetary policy**: Gertler and Karadi (2011); Ashcraft, Garleanu, and Pedersen (2011); Kiyotaki and Moore (2012); Krishnamurthy and Vissing-Jorgensen (2013)

6. **Empirical asset pricing**: Adrian, Etula, and Muir (2011); Pedersen and Frazzini (2010, 2012); Sunderam (2013)
MODEL ROADMAP

1. Static model to illustrate core mechanism
2. Dynamic model for amplification, cycles, and effects of policy
Static model: preferences and endowment

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
- Gains from trade between \( z_1 = \psi \) and \( z_1 = 1 \) investors

2. 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 \( E_0[Y_2] = 1 \), \( \lambda_0 \) measures uncertainty
- normalize \( q_0 = 1 \), assets are the numeraire

Moreira and Savov (2015)
Static model: liquidity

1. At date 1 public signal reveals updated crash prob. \( \lambda_1 \in \{\lambda^L, \lambda^H\} \)
2. Some investors can acquire a private signal revealing asset payoff \( Y_2 \)
3. Informed trading \( \Rightarrow \) adverse selection \( \Rightarrow \) illiquidity costs
4. Costs specially high for liquidity-event investors:

**Assumption 1:** *Investors in a liquidity event trade only securities that they can sell for their present value under public information.*

5. Liquidity requires no information acquisition: trading profit < cost
6. Profit higher when (i) can trade security with high exposure to \( Y_2 \), (ii) uncertainty \( \lambda_1 \) is high

\( \Rightarrow \) Implications

- Liquid security must have low enough exposure to asset payoff
- Exposure limit tighter when uncertainty \( \lambda_1 \) is high
- Security that is liquid when \( \lambda_1 = \lambda^L \), might be illiquid when \( \lambda_1 = \lambda^H \)
Static model: securities

Intermediaries (firms) buy assets at date 0 and tranche into securities

- security \( x \) with yield \( \mu_x \), crash exposure \( \kappa_x \):

\[
\begin{align*}
  r_x^2 &= \begin{cases} 
  1 + \mu_x, & \text{if } Y_2 = 1 + \mu_Y \quad \text{(normal times)} \\
  1 - \kappa_x, & \text{if } Y_2 = 1 - \kappa_Y \quad \text{(crash)}
\end{cases}
\end{align*}
\]

Proposition 1 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.

\( \Rightarrow \) These securities are issued because they have the highest crash exposure within their liquidity profile. They economize on collateral.
Balance sheet view

Assets

\[ Y_2 \]

- Crash exposure: \( \kappa Y \)
- Crash collateral: \( 1 - \kappa Y \)

Intermediaries

<table>
<thead>
<tr>
<th>Assets</th>
<th>Liabilities</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crash exposure: ( \kappa Y )</td>
<td>Equity: ( e_0 )</td>
</tr>
<tr>
<td>Crash collateral: ( 1 - \kappa Y )</td>
<td>Shadow money: ( s_0 )</td>
</tr>
<tr>
<td>Money: ( m_0 )</td>
<td></td>
</tr>
</tbody>
</table>

Investors

- Wealth: \( m_0 + s_0 + e_0 = 1 \)
- Overall liquidity: \( m_0 + s_0 \)
- Stable liquidity: \( m_0 \)

Moreira and Savov (2015)
Static model: equilibrium

Equilibrium allocation solves

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

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

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

and the collateral constraint

$$m_0 + s_0 (1 - \kappa) \leq 1 - \kappa_Y.$$

**Equilibrium security issuance:**

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

(low uncertainty, liquidity supply large but fragile);

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

(high uncertainty, liquidity supply small but stable);

$\Rightarrow$ Trade-off between quantity and stability of the liquidity supply
MODEL ROADMAP

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

Investors maximize

$$V_0 = \max E_0 \left[ \int_0^\infty e^{-\rho t} W_t \left( \psi d\xi_t \, dz_t + c_t \, dt \right) \right],$$

(1)

- $dz_t = 1$ denote a liquidity event, Poisson with intensity $h$

- $d\xi_t \leq \bar{\xi}_t$ where $\bar{\xi}_t \sim \text{Exp}(\eta)$ i.i.d.

  * leads to decreasing demand for liquidity
  * each additional dollar of liquidity more likely to go unused

- both $dz_t$ and $\bar{\xi}_t$ independent across investors
Capital accumulation

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

\[
\frac{dk_t^a}{k_t^a} = \left[ \phi^a (\iota_t^a) - \delta \right] dt - \kappa^a dZ_t \\
\frac{dk_t^b}{k_t^b} = \left[ \phi^b (\iota_t^b) - \delta \right] dt 
\]

- investment \( \iota_t^a, \iota_t^b \); adjustment cost \( \phi'' < 0 \); depreciation \( \delta \)

- \( dZ_t \sim \) compensated (mean-zero) Poisson “crash”, exposure \( \kappa^a > 0 \)

- intensity \( \lambda_t \), measures uncertainty

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 $\varphi$
   - 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”)

\[ d\lambda_t = \varphi (\bar{\lambda} - \lambda_t) \, dt + \sum_t \left( \nu dB_t + \frac{1}{\lambda_t} dZ_t \right), \]

$\sum_t \equiv \text{Var}_t\left(\tilde{\lambda}_t\right) = (\lambda^H - \lambda_t) (\lambda_t - \lambda^L)$

$\nu$ is the precision of the Brownian signal
Markets

1. Assets claims to one unit of capital. Asset prices $q^i_t = q^i(\lambda_t, \chi_t)$

$$
\frac{dq^i_t}{q^i_t} = \mu^i_{q,t} dt + \sigma^i_{q,t} dB_t - \kappa^i_{q,t} dZ_t, \ i = a, b
$$

2. Intermediaries again tranche assets into securities. With two shocks $(dZ_t, dB_t)$, a generic security $x$’s return has form

$$
dr^x_t = \mu^x_{x,t} dt + \sigma^x_{x,t} dB_t - \kappa^x_{x,t} dZ_t. \quad (3)
$$

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

\[ \rho V_t dt = \max_{m_t, s_t, \psi} E_t \left[ W_t \left( \psi d_{t} \psi dt + c_t dt \right) \right] + E_t [dV_t] \]

subject to \( c_{t} \psi \leq \bar{c}_{t} \psi \) and the budget and liquidity constraints

\[
\frac{dW}{W} = dr^e_t + m_t (dr^m_t - dr^e_t) + s_t (dr^s_t - dr^e_t) - c_t dt - dc_{t} \psi dz_t
\]

\[ dc_{t} \psi \leq \begin{cases} m_t + s_t & \text{prob. } 1 - p_H(\lambda_t) \\ m_t & \text{prob. } p_H(\lambda_t) \end{cases} \]

Risk-neutrality implies the problem simplifies to

\[ \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 \left( \bar{c}_{t} \psi \right) \ight.

\[ + p_H(\lambda_t) \int_0^\infty \min\{\bar{c}_{t} \psi, m_t\} dF \left( \bar{c}_{t} \psi \right) \left] + \mu W, t. \right. \]

where \( F(\bar{c}_{t} \psi) = \text{Exp}(\eta) \) the liquidity size distribution
Proposition (Securities expected returns)

The liquidity premium

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

The shadow-money money spread

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

The aggregate discount rate

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

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

Intermediaries maximize present value of profits

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

subject to the collateral constraint

\[ m_t + s_t (1 - \kappa_t) \leq 1 - \kappa_{A,t}, [\theta_t] \]

Aggregate collateral is value weighted sum of asset collateral values

\[ 1 - \kappa_{A,t} = \chi^q_t (1 - \kappa^a_t) \left( 1 - \kappa^a_{q,t} \right) + (1 - \chi^q_t) \left( 1 - \kappa^b_t \right), \]

- collateral values depend on the endogenous price exposure.
- \( \theta \) low when B supply high or demand for shadow money high.
Intermediaries: asset prices and investment

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

\[ q^i_t = \frac{y^i - \nu^i_t}{\left( \mu_W, t - \theta_t \left[ (1 - \kappa^i_t) - (1 - \kappa_{A,t}) \right] \right) - \left[ \mu_q, t + \kappa^i_k \kappa^i_{q,t} \lambda_t + \phi \left( \nu^i_t \right) - \delta \right]} \]

- Collateral rich asset B discounted at lower rate than asset A
- Difference higher when collateral premium \( \theta \) is high
- Asset B tends to appreciate in a crash, \( 1 - \kappa^b_{q,t} > 1 \) (\( \theta \uparrow \))

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

\[ 1 = q^i_t \phi' (\nu^i_t), \quad i = a, b. \]
Intermediaries and the supply of liquidity

\[ m_t + s_t (1 - \kappa) \leq 1 - \kappa_{A,t} \]

\[ m_t + s_t \leq 1 \]

Shadow money

Money

Moreira and Savov (2015)
Proposition (Equilibrium security issuance)

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

i. \((\text{boom})\) if \(\mathcal{M}_t > \min \left\{ \frac{\kappa_{A,t}}{\kappa}, \frac{1-\kappa_{A,t}}{1-\kappa} \right\}, \)

\[
m_t = \max \left\{ 0, 1 - \frac{\kappa_{A,t}}{\kappa} \right\} \quad \text{and} \quad s_t = \min \left\{ \frac{1-\kappa_{A,t}}{1-\kappa}, \frac{\kappa_{A,t}}{\kappa} \right\},
\]

ii. \((\text{recovery})\) if \(0 \leq \mathcal{M}_t \leq \min \left\{ \frac{\kappa_{A,t}}{\kappa}, \frac{1-\kappa_{A,t}}{1-\kappa} \right\}, \)

\[
m_t = 1 - \kappa_{A,t} - \left(1 - \frac{1}{\kappa}\right) \mathcal{M}_t \quad \text{and} \quad s_t = \mathcal{M}_t; \quad \text{and}
\]

iii. \((\text{bust})\) 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.
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 $\chi$).

Moreira and Savov (2015)
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).
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 $\chi$ 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

Moreira and Savov (2015)
Collateral runs

1. Collateral values fall as prices fall ⇒ 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

Moreira and Savov (2015)
EFFECTS OF POLICY INTERVENTIONS
QE1 - Large-Scale Asset Purchases

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

\[
\begin{align*}
\text{Announcement effect on } a \text{ price} & \quad \text{Announcement effect on } b \text{ price} \\
\text{Ex ante effect on } a \text{ price } q^a & \quad \text{Ex ante effect on } b \text{ price } q^b
\end{align*}
\]

\[
\begin{align*}
\lambda^L & \quad \lambda^H & \quad \lambda^L & \quad \lambda^H \\
5 \times 10^{-3} & \quad 0 & \quad -0.01 & \quad -0.03 \\
-5 & \quad 0 & \quad -0.02 & \quad 0 \\
\lambda & \quad \lambda & \quad \lambda & \quad \lambda \\
0 & \quad 0 & \quad 0 & \quad 0 \\
0.2 & \quad 0.2 & \quad 0.2 & \quad 0.2 \\
0.4 & \quad 0.4 & \quad 0.4 & \quad 0.4 \\
0.6 & \quad 0.6 & \quad 0.6 & \quad 0.6 \\
0.8 & \quad 0.8 & \quad 0.8 & \quad 0.8 \\
\lambda^H & \quad \lambda^H & \quad \lambda^H & \quad \lambda^H
\end{align*}
\]

- --- \( \chi = 0.75 \) (high collateral)
- \( \chi = 0.95 \) (low collateral)

Moreira and Savov (2015)
QE2 - Operation Twist

   - 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 ⇒ liquidity provision falls
   ⇒ discount rates rise, especially for risky/productive assets
Liquidity requirements

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

![Diagram showing Asset a price and Aggregate collateral](image)

- **15% liquidity requirement**
- **No liquidity requirement**

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:

\[
Tbill \text{ rate} = \left( \text{aggregate discount rate} \right) - \theta_t \left( \text{collateral value of } Tbill \right)
\]

⇒ Tbill rate can be low if collateral premium $\theta_t$ 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 ($\theta_t \downarrow$)
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

*Is it better to have been liquid and lost than never to have been liquid at all?*
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. $p_H (\lambda) = (\lambda - \lambda^L) / (\lambda^H - \lambda^L)$.

<table>
<thead>
<tr>
<th>Description</th>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Technology:</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Asset cash flows</td>
<td>$y^a, y^b$</td>
<td>0.138, 0.1</td>
</tr>
<tr>
<td>Depreciation rate</td>
<td>$\delta$</td>
<td>0.1</td>
</tr>
<tr>
<td>Exogenous aggregate growth</td>
<td>$\mu_0$</td>
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<td>Adjustment cost parameter</td>
<td>$\gamma$</td>
<td>3</td>
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<tr>
<td>Asset crash exposures</td>
<td>$\kappa^a, \kappa^b$</td>
<td>0.5, 0</td>
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<tr>
<td><strong>Information sensitivity constraint:</strong></td>
<td></td>
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<tr>
<td>Crash exposure limit for fragile liquid securities</td>
<td>$\bar{\kappa}$</td>
<td>0.7</td>
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<tr>
<td><strong>Uncertainty:</strong></td>
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<td></td>
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<tr>
<td>Low/high uncertainty states</td>
<td>$\lambda^L, \lambda^H$</td>
<td>0.005, 1</td>
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<tr>
<td>Average uncertainty</td>
<td>$\overline{\lambda}$</td>
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<tr>
<td>Uncertainty rate of mean reversion</td>
<td>$\varphi$</td>
<td>0.5</td>
</tr>
<tr>
<td>Uncertainty news signal precision</td>
<td>$1/\sigma$</td>
<td>0.1</td>
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<td><strong>Preferences and liquidity events:</strong></td>
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<tr>
<td>Liquidity event frequency</td>
<td>$h$</td>
<td>0.28</td>
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<tr>
<td>Liquidity event marginal utility</td>
<td>$\psi$</td>
<td>5</td>
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<tr>
<td>Average size of liquidity event</td>
<td>$1/\eta$</td>
<td>0.33</td>
</tr>
<tr>
<td>Subjective discounting parameter</td>
<td>$\rho$</td>
<td>0.37</td>
</tr>
</tbody>
</table>

Moreira and Savov (2015)
Uncertainty shock impulse responses

- **Uncertainty** $\lambda$
- **Capital mix** $\chi$
- **Log output** $\log Y$
- **Asset a price** $q^a$
- **Asset b price** $q^b$
- **Aggregate collateral** $1 - \kappa_A$

---

*Moreira and Savov (2015)*
Crash shock impulse responses

Uncertainty $\lambda$

Capital mix $\chi$

Log output $\log Y$

Asset $a$ price $q^a$

Asset $b$ price $q^b$

Aggregate collateral $1 - \kappa_A$

Without shadow banking — With shadow banking

Moreira and Savov (2015)