Self-Fulfilling Runs:
Evidence from the U.S. Life Insurance Industry

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The views expressed in this paper do not necessarily reflect the views of the Board of Governors of the Federal Reserve System, or its staff
Is shadow banking vulnerable to self-fulfilling runs?

• Traditional banks fund illiquid assets with demand deposits
  • Run triggered by concerns about the bank’s fundamentals
  • Amplified by strategic complementarity in withdrawal
    \[\rightarrow \text{Self-fulfilling component of runs}\]

• Shadow banking is made up of chains of intermediaries

• Empirical challenge is to address the reflection problem

At least 40 percent of a run by short-term institutional investors on U.S. life insurers in the Fall of 2007 can be attributed to the self-fulfilling component
Funding agreement-backed securities (FABS)

- U.S. life insurers are increasingly connected to shadow banking

<table>
<thead>
<tr>
<th>Life Insurer</th>
<th>FABS are insurance obligations</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Assets</strong></td>
<td><strong>Liabilities</strong></td>
</tr>
<tr>
<td>Treasuries</td>
<td>Insurance Policies</td>
</tr>
<tr>
<td>Agencies</td>
<td>Funding Agreement</td>
</tr>
<tr>
<td>Mortgages</td>
<td></td>
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<td>ABS Corporates</td>
<td></td>
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</table>

**SPV**

<table>
<thead>
<tr>
<th>Assets</th>
<th>Liabilities</th>
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<tbody>
<tr>
<td>Notes to Investors</td>
<td>Cash</td>
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<tr>
<td>FABS</td>
<td>Funding Agreement</td>
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</tbody>
</table>

- FABS market peaked at over $170 billion in 2007
- FABS can be issued under various terms and with put options to meet demand from different types of **short-term investors**
Extendible FABS issued to MMFs experienced a run

- Long-term bonds with periodic options for early withdrawal
- In normal times, all investors opt to extend on election dates
- From 2007Q3, short-term investors exercised their put
Strategic complementarity in withdrawals

- Other investors could exercise their put and get ahead
- Variation in the amount of bonds that can be put back
- Current theories abstract from time-varying liability structure
Environment

- Continuous time

- A firm finances an asset paying
  - a constant stream of coupon $r$
  - 1 at a random maturity date with Poisson arrival rate $\phi$
  - $\nu_D < 1$ if it defaults before maturity with arrival rate $\pi$

- Issues bonds to risk neutral investors with discount rate $\rho$
Investors have the option to put the bond back to the firm

- Bonds can be in two states $S \in \{N, E\}$:
  - $N$: The put cannot be exercised
  - $E$: The put may be *Exercised* with arrival rate $\delta$

- **Withdrawal** pays $1$ minus i.i.d. cost $\omega$ from distribution $\Omega$

- Fraction $e \in [0, 1]$ of bonds in $E$ changes with arrival rate $\varepsilon$,
  $e'$ drawn from Beta($\alpha, \beta$) with $\alpha = e \cdot \eta$ and $\beta = (1 - e) \cdot \eta$

- Bonds may mature before the asset with arrival rate $\zeta$
Weak asset fundamentals $\pi > \frac{r - \rho}{1 - \nu_D}$ and $\varepsilon = 0$
Weak asset fundamentals and $\varepsilon > 0$
Strategic complementarities amplify the effect of weak asset fundamental

- During the run, the firm may rollover by issuing new bonds
- Or be forced to liquidate the asset with arrival rate $\theta \cdot e \cdot \hat{\Omega}$
  - $\theta$: run externality
  - $e \cdot \hat{\Omega}$: flow of withdrawals
  - $\hat{\Omega}$: fraction of investors exercising their put option
- The asset liquidation value during a run is $\nu_L < 1$
\[ \varepsilon = 0 \text{ and } \theta > 0 \]
Bond value $V^S$ depends on other investors’ valuation $\bar{V}$

$$
\rho V^S (e; \bar{V}) = \varepsilon \cdot (E_{e'}|e[e' \cdot V^E (e'; \bar{V}) + (1-e') \cdot V^N (e'; \bar{V})] - V^s)
$$

**variations in liability structure**

$$
\pi_s \cdot (\nu_D - V^s)
$$

**variations in fundamentals**

$$
\nu + \phi \cdot (1 - V^s)
$$

**coupon and asset maturity payoff**

$$
\varepsilon \cdot \eta \cdot (1 - V^s)
$$

**bond maturity**

$$
1_{\{S = E\}} \delta \cdot (E_{\Omega} \max \{V^s, 1 - \omega\}) - V^s
$$

**put option**

$$
\theta \cdot e \cdot \Omega (1 - \bar{V}^s (e)) \cdot (\nu_L - V^s)
$$

**strategic complementarity: run externality**
In a symmetric equilibrium with small $\varepsilon$ and $\theta > 0$, the forced liquidation rate is $\theta \cdot e \cdot \hat{\Omega} = \theta \cdot e \cdot \Omega(1 - V^E(e))$.\[\omega \ll \begin{cases} V^E(\tilde{e}) \\ 1 \end{cases} \text{weak asset fundamental strategic complementarity}\]
Mapping the model to data

- $D_{it}$: Fraction of extendible FABS $i$ withdrawn on day $t$
  - $D_{it} \sim \Omega(1 - V^E(e))$
- $RE_{it+m_i}$: fraction of $j \neq i$ that can be withdrawn in $(t, t + m_i)$
  - $RE_{it+m_i} \sim e$
- Use variations in $RE_{it+m_i}$ that is orthogonal to fundamentals
Structural estimation of the self-fulfilling component

- 13 life insurers; 54 Ext. FABS; 106 early withdrawals; 924 observations
- Calibrate common and insurer-specific parameters
- Estimate key parameters \( \{\theta, \pi\} \) using IV-GMM

\[
\mathbb{E} \left[ D_{it} - \hat{D}_{it} \right] = \mathbb{E} \left[ D_{it} - \Omega \left( 1 - \hat{V}^E \left( R_{Eit + m_i} \right) \right) \right] = 0
\]

- IV-GMM accounts for the investors’ information set

\[
\mathbb{E} \left[ (D_{it} - \hat{D}_{it})Z_{it} \right] = 0, \text{ for all } t = 1, \ldots, T
\]

where \( Z_{it} \) are predetermined variables
Small concerns about asset fundamentals have large effects on withdrawals with strategic complementarities

- $\hat{\theta}^{IVGMM} > 0$: existence of strategic complementarities

- $\hat{\pi}^{IVGMM} = 0.005$: Asset default is a 1-in-200 year event!

- Model accounts for over 95% of observed withdrawals
  - Asset fundamentals account for at most 60%
  - Self-fulfilling component accounts for at least 40%
Conclusion

- Framework to study the effects of strategic complementarities
- Evidence of a sizeable self-fulfilling component to a run
- Runs by the same short-term investors on ABCP and repo
  - Citigroup’s putable CDO was a primary cause of 2008 bailout
  - ABCP sponsors that experienced runs look similar to FABS issuers
- Unlike runs on MMFs, runs by MMFs have been neglected
- Other applications: sovereign debt crisis, empty creditors, etc
Appendix

Econometric IV specification

Observations: election $t$ of extendible FABS $i$ from insurer $k$

\[ D_{ijt} = \gamma_{i0} + \gamma_1 S_{it+m_i}^k + \gamma_2 Q_{it}^k + X_{it}^k \beta + \epsilon_{it}^k \]

\[ S_{it+m_i}^k = \alpha_{i0} + \alpha_1 REex3m_{it+m_i}^k + \alpha_2 Q_{it}^k + X_{it}^k \rho + \nu_{it}^k \]

- $D_{it}^k$ fraction of extendible FABS $i$ withdrawn on $t$
  - Next election on $t + m_i^k$
- $S_{it+m_i}^k$ fraction of extendible FABS withdrawn in $(t, t + m_i^k)$
- $REex3m_{it+m_i}^k$ fraction that becomes putable in $(t, t + m_i^k)$
- $Q_{it}^k$ fraction of extendible FABS withdrawn prior to $t$
- $X_{it}^k$ insurer, aggregate and time controls
IV reduced form regression, in a graph

- 13 life insurers; 54 Ext. FABS; 106 early withdrawals; 924 observations
## Instrumental variable results

<table>
<thead>
<tr>
<th>Dependent variable: $D_{it}^k$</th>
<th>Baseline</th>
<th>Weekly FE</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1\textsuperscript{st} stage</td>
<td>2\textsuperscript{nd} stage</td>
</tr>
<tr>
<td>$S_{it+m_i}^k$</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>2.124***</td>
<td>1.606**</td>
</tr>
<tr>
<td>$REex3m_{it+m_i}^k$</td>
<td>0.125***</td>
<td>0.067***</td>
</tr>
<tr>
<td>$Q_{it}^k$</td>
<td>Y</td>
<td>Y</td>
</tr>
<tr>
<td>Insurer FE</td>
<td>Y</td>
<td>Y</td>
</tr>
<tr>
<td>Week FE</td>
<td>N</td>
<td>N</td>
</tr>
<tr>
<td>Observations</td>
<td>747</td>
<td>747</td>
</tr>
</tbody>
</table>

Robust standard errors in parentheses. *** $p < 1\%$, ** $p < 5\%$
Illiquidity and insurers: The Hartford

- Insurers’ insolvency is rarely a concern for investors
- AIG 2008: $450bn life subsidiary had $13bn sec lending losses
- ... 
- The Hartford 2007: $360bn, $6.5bn FABS, $2.4bn XFABN 
- Jan-Oct 2008: investors withdraw, $2.7bn due, no roll over 
- Oct 2008: Access CPFF and Allianz injection ($2.5bn)
- Nov 2008: CP downgrade, applied to CPP, converted to S&L
- 2009: Changed statutory reporting, accessed TARP 
- **The Hartford survived** but exited the life business
• Universe of U.S. FABS at a daily frequency

• Extendible FABS:
  • 13 life insurers; 54 XFABS; 106 Spinoffs
  • CUSIP, issue date, initial and final maturity, election dates
  • Amount withdrawn (spinoffs) at every election dates
  • Every spinoff matched to its parent XFABS

• Statutory filings, Ratings, CDS, VIX, ABCP, etc.

• Sample: January 1, 2005 to December 31, 2010

→ 924 insurer-security-election date observations
Structural estimation of self-fulfilling component

- Discount factor $(\rho)$: 1m Tbill rate at Jan 2007
- Coupon $(r)$: average rate observed at Jun 2007
- Cost distribution: $\omega \sim U[0, 1]$

1. Separately estimate insurer-specific parameters:
   - Underlying asset maturity rate $(\phi)$: inverse age of conduits
   - Election date rate $(\delta)$: average election periodicity
   - Putable maturity rate $(\epsilon)$: average election rate 2007-2008
   - Putables maturing $(\epsilon \cdot \eta)$: inverse average residual maturity
## Data summary statistics

<table>
<thead>
<tr>
<th>Variable</th>
<th>Obs.</th>
<th>Median</th>
<th>Mean</th>
<th>Std. Dev.</th>
<th>Min</th>
<th>Max</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of XFABS</td>
<td>54</td>
<td>.</td>
<td>.</td>
<td>.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number of spinoffs</td>
<td>106</td>
<td>.</td>
<td>.</td>
<td>.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>XFABS election dates</td>
<td>1129</td>
<td>.</td>
<td>.</td>
<td>.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Days b/t election dates</td>
<td>1076</td>
<td>31</td>
<td>47.3</td>
<td>35.9</td>
<td>28</td>
<td>365</td>
</tr>
<tr>
<td>XFABS issue amt (USDm)</td>
<td>53</td>
<td>350</td>
<td>465.4</td>
<td>333</td>
<td>100</td>
<td>2000</td>
</tr>
<tr>
<td>Spinoff issue amt (USDm)</td>
<td>106</td>
<td>134.5</td>
<td>191.5</td>
<td>193.3</td>
<td>.2</td>
<td>1338.5</td>
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<tr>
<td>Spinoff maturity (days)</td>
<td>53</td>
<td>367</td>
<td>504.7</td>
<td>215</td>
<td>302</td>
<td>1006</td>
</tr>
<tr>
<td>Dependent var ($D_{ijt}$)</td>
<td>768</td>
<td>0</td>
<td>0.1</td>
<td>0.3</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Endogenous var ($S_{ijt+1}$)</td>
<td>914</td>
<td>0</td>
<td>0</td>
<td>0.1</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Instrument ($REex3m_{ijt+1}$)</td>
<td>1028</td>
<td>0.44</td>
<td>0.44</td>
<td>0.35</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Maturing FABS ($Q_{ijt}$)</td>
<td>1076</td>
<td>0.2</td>
<td>0.18</td>
<td>0.15</td>
<td>0</td>
<td>1</td>
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