# Systemic risk and the solvency-liquidity nexus of banks

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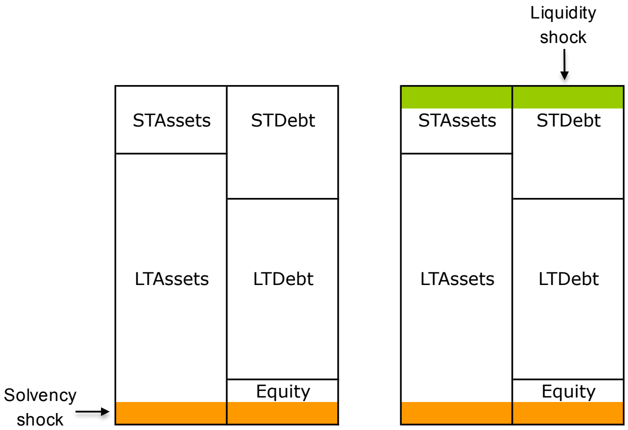
# Solvency and liquidity risks

- **Solvency risk**: the bank needs enough *Equity* to cover its *Asset* losses
- **Funding liquidity risk**: the bank needs enough *Short-term (liquid) assets* to settle its obligations (repay *Short-term debt* creditors) with immediacy



# The solvency-liquidity nexus of banks

The solvency-liquidity nexus in the (theoretical) economic literature:

1. Bank runs are based on the strength of the bank's fundamentals (Allen and Gale (1998), Gorton (1988))
2. "Liquidity and solvency problems interact and can cause each other, making it hard to determine the cause of a crisis" (Diamond and Rajan (2005))
3. The role of systemic risk through fire-sales liquidation costs (Shleifer and Vishny (1992))

The solvency-liquidity nexus is absent from capital and liquidity regulations (Basel III), and has not been the center of empirical studies.

In this paper, **I test the empirical solvency-liquidity nexus of banks** by examining the interaction between their short-term balance sheets and their solvency risk measures.

# Macroprudential regulation of liquidity risk

- Liquid asset requirements are not sufficient from a macroprudential perspective:

"*Even if an intermediary's book of securities financing transactions is perfectly matched,* ***a reduction in its access to funding can force the firm to engage in asset fire sales or to abruptly withdraw credit from customers.***" (Tarullo, May 2013)

- Macroprudential regulation of liquidity risk is a subtle combination of liquid asset and additional capital requirements:

"*A more interesting approach would be to* ***tie liquidity and capital standards together*** *by requiring higher levels of capital for large firms unless their liquidity position is substantially stronger than minimum requirements.*" (Tarullo, May 2013)

"*Balance sheet repair will give confidence to depositors and investors who provide funding to banks.* ***With that market funding assured, banks can safely hold fewer liquid assets***" (Carney, August 2013)

# Outline

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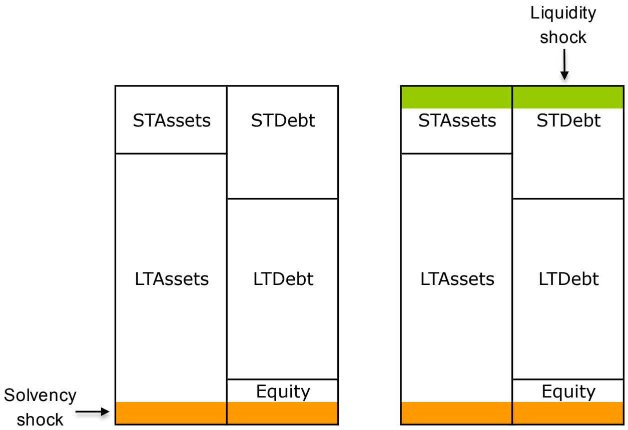
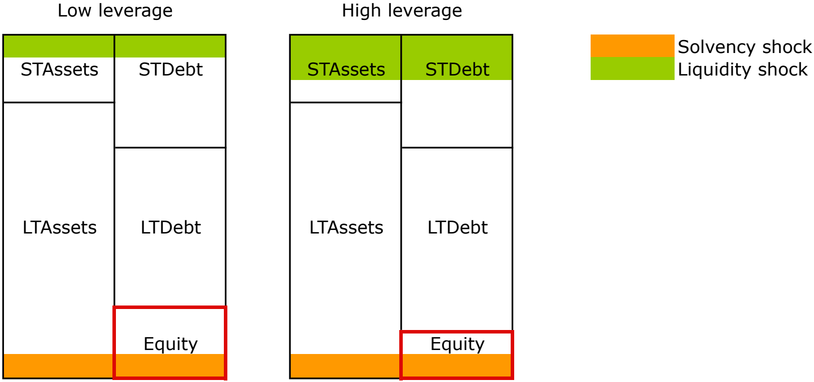


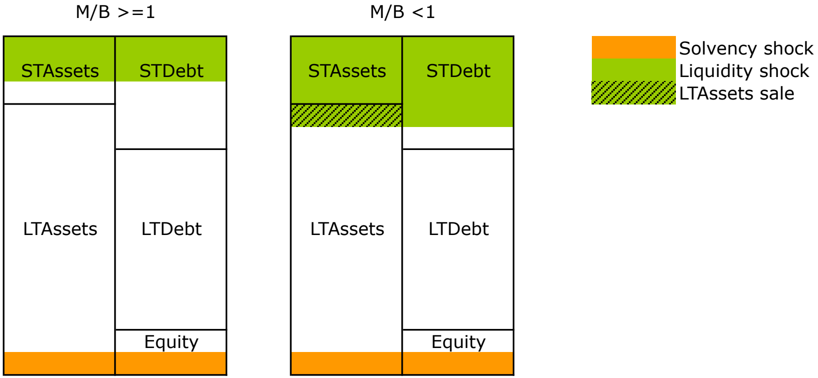
# Impact of book leverage

Short-term creditors run faster from a bank with **higher leverage** (higher risk of insolvency).



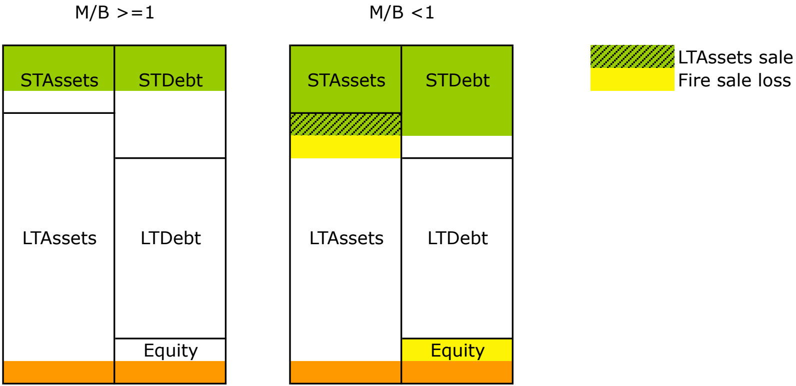
# Impact of market values

Short-term creditors run faster from a bank with **low market-to-book ratio** (M/B), i.e. when the market perception of its leverage is higher than its book leverage.



# Fire sales

Under aggregate stress: multiple banks rush to sell their long-term (illiquid) assets, the bank will sell its long-term assets at a **fire-sale loss**, increasing its risk of becoming insolvent.



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# Liquidity risk and the short-term balance sheet

Short-term balance sheet of 44 BHCs over 2000Q1-2013Q1 (FR Y-9C)

- Short term debt = Fed funds purchased + repos + (uninsured time deposits + other borrowed money)$_{mat \leq 1yr}$.
- Short term assets = interest-bearing bank balances (cash) + Fed funds sold + reverse repos + (debt securities)$_{mat \leq 1yr}$.

**Funding liquidity risk**: the bank needs enough liquid assets to settle its obligations (repay creditors) with immediacy

- Liquid asset shortfall$_{it}$ $= STDebt_{it} - STAssets_{it}$
- Basel Liquidity coverage ratio: $LCR_{it} = \frac{STAssets_{it}}{w'_{FL} STDebt_{it}}$

# Solvency risk measures

**Solvency risk**: the bank needs enough capital to cover its asset losses

- SRISK: the capital a firm would need to raise in the event of a crisis (Acharya et al. (2010, 2012); Brownlees and Engle (2011))

$$\begin{aligned} SRISK_{it} &= \mathrm{E}_t\left[k(Debt_{it+h} + MV_{it+h}) - MV_{it+h} | R_{mt+h} \leq -40\%\right] \\ &= kDebt_{it} - (1-k)(1 - LRMES_{it}) * MV_{it} \end{aligned}$$

  where $MV_{it}$ is the market value of equity of the bank, $LRMES_{it}$ is its long-run marginal expected shortfall, and $k$ is the prudential capital ratio.

- Regulatory capital ratios
  - Tier 1 capital ratio: $\mathrm{T1CR}_{it} \simeq \frac{Equity_{it}}{w'_{AR} LTAssets_{it}}$
  - Tier 1 leverage ratio: $\mathrm{T1LVGR}_{it} \simeq \frac{Equity_{it}}{LTAssets_{it} + STAssets_{it}}$
- Market measures of risk (realized volatility, expected shortfall, market beta)

# Testing the solvency-liquidity nexus with a panel VAR

Let $y_{it} = \ln(STDebt_{it})$ and $z_{it} = \ln(STAssets_{it})$.

The solvency-liquidity nexus is tested using a fixed-effects panel vector autoregressive (VAR) model for $w_{it} = (y_{it,}, z_{it}, SRISK_{it}/TA_{it})'$

$$w_{it} = \alpha_i + \phi_i \odot w_{it-1} + \theta_i t + \delta w_{it-1} + \varepsilon_{it}$$

where $\alpha_i$, $\phi_i$, and $\theta_i$ are bank-specific parameters and $\delta$ is a square matrix of parameters with zeros on the diagonal (interaction parameters).

# Testing the solvency-liquidity nexus

A bank with a large expected capital shortfall in a crisis (SRISK) loses its access to short-term funding. Conversely, a bank with more short-term debt has a higher risk of insolvency in a crisis.

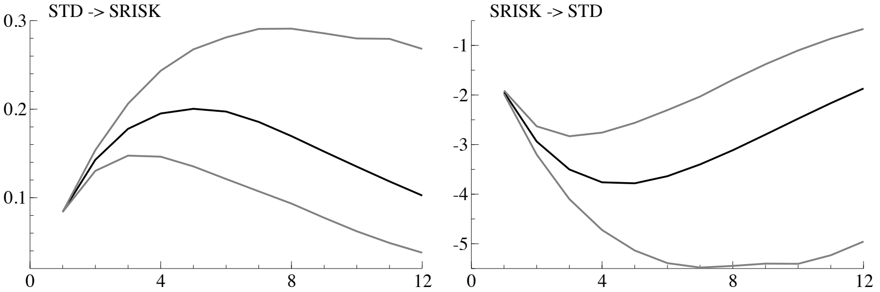
| Dep. variable | $y_{it}$ | $z_{it}$ | $(\text{SRISK/TA})_{it}$ |
|---|---|---|---|
| $(\text{SRISK/TA})_{it-1}$ | **-1.120**** | 0.074 | |
| | **(0.244)** | (0.114) | |
| $z_{it-1}$ | -0.040 | | -0.001 |
| | (0.023) | | (0.002) |
| $y_{it-1}$ | | -0.003 | **0.009**** |
| | | (0.022) | **(0.002)** |
| $R^2$ (%) | 20.811 | 22.157 | 15.151 |
| Adj. $R^2$ (%) | 15.430 | 16.868 | 9.429 |

Table 1: **The solvency-liquidity nexus.** Estimates from pooled OLS regression with bank dummies, time trends, and heterogeneous AR parameters. Dependent variables: $y_{it} = \ln(STDebt_{it})$, $z_{it} = \ln(STAssets_{it})$, $(SRISK/TA)_{it} = SRISK_{it}/TotalAssets_{it}$. Robust standard errors in parentheses. * significant parameter at 5%; ** at 1%. Sample: 2107 panel obs. over 2000Q1-2013Q1 (unbalanced), 44 banks. SRISK is the expected capital shortfall of the bank in a crisis.

# The solvency-liquidity nexus: heterogeneity in responses to shocks

Median impulse response function (black), between 25% and 75% quantiles (grey)

For some banks the impact of SRISK shocks on short-term funding vanishes after 3 years, for other banks the solvency shocks have a more permanent impact.



# Interaction between solvency and profitability

One way to disentangle between supply and demand effects on the bank characteristics is to augment the model with a state variable

$$w_{it} = \alpha_i + \phi_i \odot w_{it-1} + \theta_i t + \delta w_{it-1} + \gamma w_{it-1} * s_{it-1} + \omega s_{it-1} + \varepsilon_{it}$$

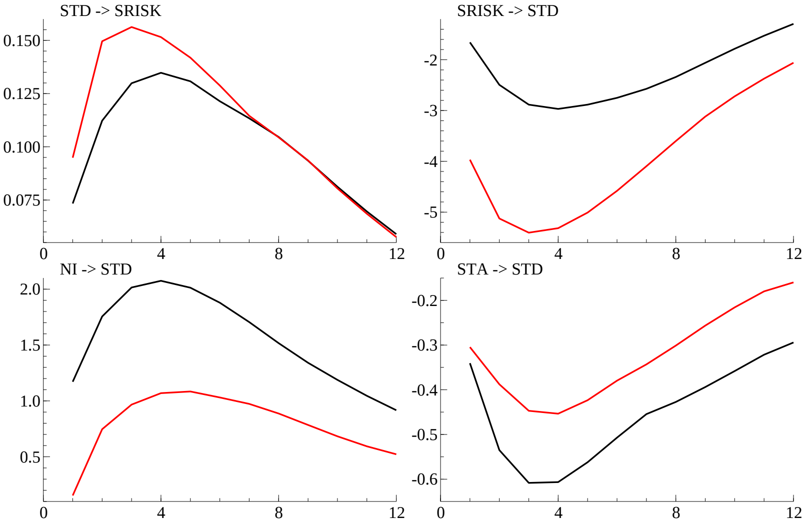
where the state variable $s_{it} = 1_{\{SRISK_{it}>0\}}$.

The profitability of the bank predicts its ST Debt level *only* when it is adequately capitalized (as $\delta_{NI} + \gamma_{NI} \simeq 0$).

| Dep. variable | $y_{it}$ | $z_{it}$ | $y_{it}$ | $z_{it}$ |
|---|---|---|---|---|
| $(\text{SRISK/TA})_{it-1}$ | -1.063** | -0.028 | -0.935** | -0.120 |
| | (0.245) | (0.118) | (0.261) | (0.101) |
| $(\text{SRISK/TA})_{it-1} * s_{it-1}$ | | | -0.408 | 1.757* |
| | | | (0.751) | (0.767) |
| $(\text{NI/TA})_{it-1}$ | 2.354 | -4.228 | 9.704** | -7.944* |
| | (2.278) | (2.331) | (3.290) | (3.716) |
| $(\text{NI/TA})_{it-1} * s_{it-1}$ | | | -9.902* | 6.315 |
| | | | (4.396) | (5.183) |
| $R^2$ (%) | 20.870 | 22.318 | 21.278 | 22.562 |
| Adj. $R^2$ (%) | 15.450 | 16.997 | 15.715 | 17.089 |

# Impulse response functions (impact of SRISK>0)

Median impulse response when $SRISK_{it} \leq 0$ (black) vs. median impulse response when $SRISK_{it} > 0$ (red)



# What works in SRISK?

$$\frac{SRISK_{it}}{TA_{it}} = \frac{MV_{it}}{TA_{it}} \{k(Lvg_{it} - 1) - (1-k)(1 - LRMES_{it})\}$$

| | (1) | | (2) | | (3) | | (4) | | (5) | | (6) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Dep. variable | $y_{it}$ | $z_{it}$ | $y_{it}$ | $z_{it}$ | $y_{it}$ | $z_{it}$ | $y_{it}$ | $z_{it}$ | $y_{it}$ | $z_{it}$ | $y_{it}$ | $z_{it}$ |
| $(SRISK/TA)_{it-1}$ | **-1.439**** | 0.010 | | | | | | | | | | |
| | **(0.105)** | (0.110) | | | | | | | | | | |
| $LRMES_{it-1}$ | | | -0.162 | 0.205 | | | | | | | -0.080 | 0.195 |
| | | | (0.096) | (0.111) | | | | | | | (0.110) | (0.117) |
| $Lvg_{it-1}$ | | | | | -0.002 | 0.001 | | | | | -0.002 | 0.000 |
| | | | | | (0.001) | (0.001) | | | | | (0.001) | (0.001) |
| $(MV/TA)_{it-1}$ | | | | | | | **0.930**** | -0.002 | | | 0.925** | 0.002 |
| | | | | | | | **(0.051)** | (0.049) | | | (0.052) | (0.046) |
| $(SMV/TA)_{it-1}$ | | | | | | | | | **1.369**** | -0.021 | | |
| | | | | | | | | | **(0.080)** | (0.116) | | |
| $MB_{it-1}$ | -0.048** | -0.014 | 0.032 | -0.002 | 0.032 | -0.007 | -0.050** | -0.014 | -0.051** | -0.013 | -0.060 | -0.001 |
| | (0.016) | (0.022) | (0.025) | (0.019) | (0.027) | (0.019) | (0.019) | (0.021) | (0.016) | (0.022) | (0.020) | (0.024) |
| $R^2$ (%) | 21.110 | 22.191 | 16.714 | 22.443 | 16.701 | 22.254 | 20.725 | 22.191 | 21.338 | 22.192 | 20.931 | 22.446 |
| Adj. $R^2$ (%) | **15.749** | 16.904 | 11.055 | 17.173 | 11.041 | 16.971 | **15.338** | 16.903 | **15.993** | 16.905 | 15.473 | 17.092 |

$SMV_{it}/TA_{it} = MV_{it} * (1 - LRMES_{it})/TA_{it}$

# SRISK/TA: market shocks & 'pure' solvency shocks

MV/TA is the product of the book leverage ratio and the market-to-book ratio

$$\frac{MV_{it}}{TA_{it}} = \frac{BV_{it} * \left(\frac{MV_{it}}{BV_{it}}\right)}{TA_{it}} \simeq T1LVGR_{it} * \left(\frac{MV_{it}}{BV_{it}}\right)$$

whereas $Lvg_{it} = 1 + \frac{D_{it}}{MV_{it}}$ is not a function of the book leverage ratio.

- Book leverage ratio (T1LVGR): a 'pure' solvency measure (no information about liquidity)
- Market values: negative correlation between firms failures and book capital in a crisis.
- MV/TA is highly correlated to T1LVGR (0.91), less correlated to M/B (0.44)

**Market shocks amplify 'pure' solvency shocks**.

# Robustness of the solvency-liquidity nexus

- SRISK predicts most of the components of the short-term debt: Fed funds, repos, commercial papers, uninsured deposits
- SRISK does not predict long-term leverage
- Robustness to common factors (based on Fontaine and Garcia (2011))
- The solvency-liquidity nexus holds with
  - time dummies
  - homogenous dynamic parameters ($\phi_i = \phi, \forall i$)
  - homogenous trend parameters ($\theta_i = \theta, \forall i$)
  - no trend ($\theta_i = 0, \forall i$)
  - a break in the trend in 2008Q4
  - non-stationarity
- Forecasting the short-term balance sheet

# Summary

This paper reveals the empirical solvency-liquidity nexus of banks

1. Banks with a larger expected capital shortfall in a crisis lose access to short-term funding. Conversely, a large exposure to short-term funding increases the insolvency risk of the bank in a crisis.
2. 'Pure' solvency risk (measured by the Tier 1 leverage ratio) amplified by market shocks explains the bank access to short-term funding.
3. Solvency risk and profitability interact: a profitable bank gets a larger access to short-term funding *only* when it is adequately capitalized to survive a crisis.

New results:

- Lower solvency risk and higher deposit rates are substitutes to attract short-term funding. Insolvent banks lose access to short-term funding as they cannot afford high deposit rates (Schanz, 2011).
- Non-linearities in the solvency-liquidity nexus implied by government intervention (LOLR).