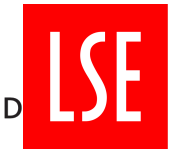

BANK OF ENGLAND

THE LONDON SCHOOL OF ECONOMICS AND POLITICAL SCIENCE
ETH zürich

NORGES BANK

Taking regulation seriously: Fire sales under solvency and liquidity constraints

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Columbia University
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Disclaimer

The views expressed are those of the authors only and do not necessarily reflect those of the Bank of England or Norges Bank.

Motivation

"During the early 'liquidity phase' of the financial crisis that began in 2007, many credit institutions, despite maintaining adequate capital levels, experienced significant difficulties because they had failed to manage their liquidity risk prudently... (Such) credit institutions were then forced to liquidate assets in a fire-sale which created a self-reinforcing downward price spiral and lack of market confidence triggering a solvency crisis."

(European Commission, 2015)

Motivation

- Liquidity issues during the crisis
- Multiple regulatory constraints
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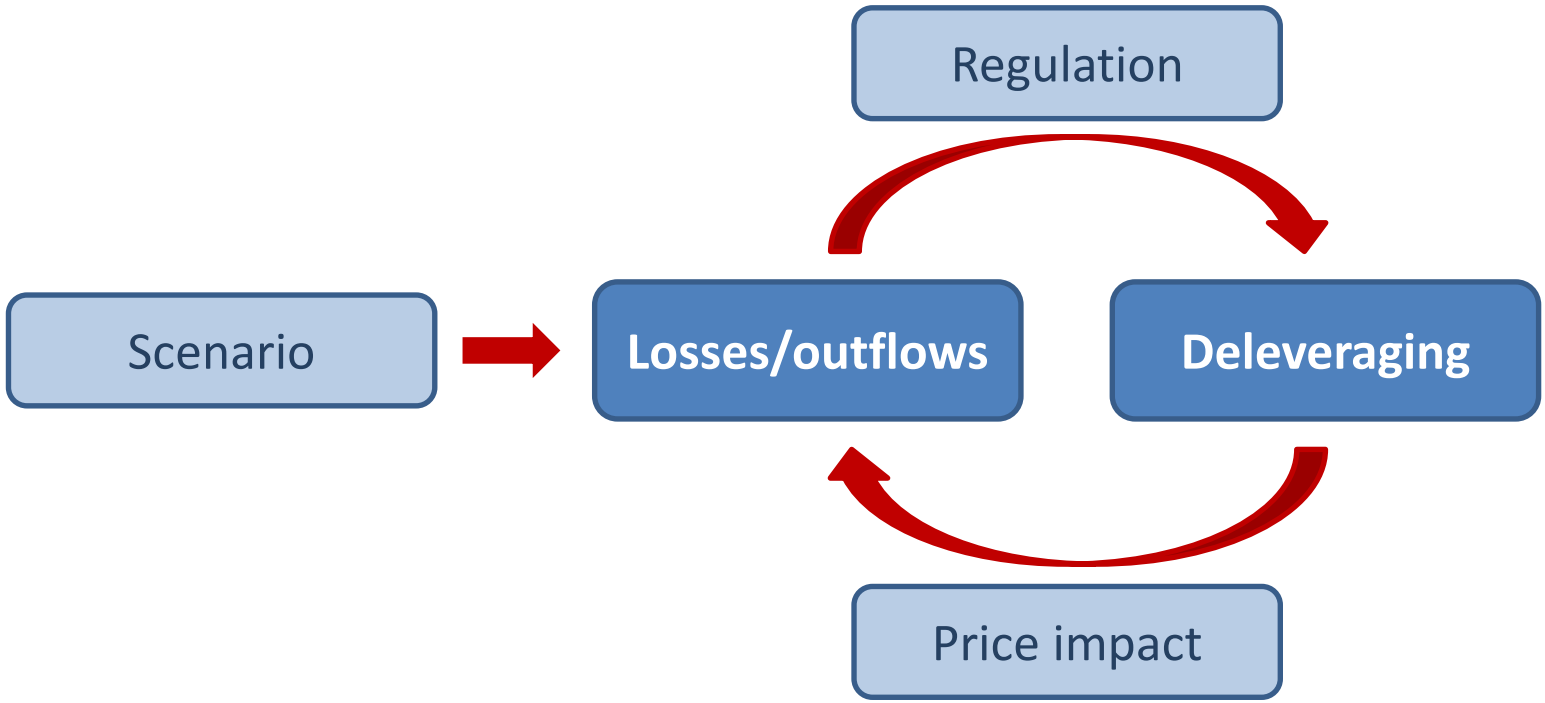
- Objectives:
  - Build a quantitative model of fire sales to assess the interaction between liquidity and solvency constraints that banks simultaneously face.
  - Which types of financial shocks and regulatory requirements combine to produce fire sales?
  - How do banks optimally liquidate their portfolios when they are forced to do so?

Literature review

- **Fire-sale models:**
  [Greenwood et al., 2015], [Cont and Schaanning, 2017],
  [Duarte and Eisenbach, 2013]
- **Constraints and optimal deleveraging:**
  [Cecchetti and Kashyap, 2016],
  [Braouezec and Wagalath, 2016]
- **Liquidity:**
  [Hellwig, 2009], [Gorton and Metrick, 2012], [Pierret, 2015] ,
  [Acharya and Merrouche, 2012]
- **Macro-stress tests:**
  [Dees and Henry, 2017], [Bank of England, 2017],
  [Bardoscia et al., 2017], [Fique, 2017],
  [Puhr and Schmitz, 2014], [Calimani et al., 2017]

Model overview



Bank balance sheets

- **Marketable securities** $M_{i,k}, k = 1...310$ and $i = 1...7$ Bonds and equity holdings that are available for sale and suffer a price impact.
- **Other assets** $O_{i,k}, k = 1, 2$: loans, intangible goods, and off-balance sheet items, which are **not** available for deleveraging.
- **Cash** or cash-like assets $C_{i,k}, k = 1, 2$.

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- **Cash** or cash-like assets $C_{i,k}, k = 1, 2$.
- **Liabilities** $L_{i,k}, k = 1...12$. These include classic retail customer deposits, institutional deposits, short-term whole-sale funding, and issued debt.
- **Capital** E_i.

Regulatory constraints

- **Risk-weighted Capital Ratio:**

$$CAP^i(A, E) := \frac{E^i}{\rho^\top A^i} \geq REG_{CAP}.$$

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- **Liquidity Coverage Ratio:**

$$LCR^i(A, C, L) := \frac{\lambda^\top M^i + \mathbf{1}^\top C^i}{\omega_{out}^\top L^i - \omega_{in}^\top A^i} \geq REG_{LCR}.$$

Shocks

We consider three type of shocks:

1. Asset shock (ϵ_A): $A_0^{i,k} = A^{i,k}(1 - \epsilon_A^k)$. (k = 1...314)
2. Funding shock (ϵ_L): $L_0^{i,k} = L^{i,k}(1 - \epsilon_L^k)$. (k = 1..12)
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$$E_0^i = (E^i - \epsilon_A^\top A^i)^+.$$
$$C_0^i = (C^i - \epsilon_L^\top L^i)^+.$$

Bank deleveraging

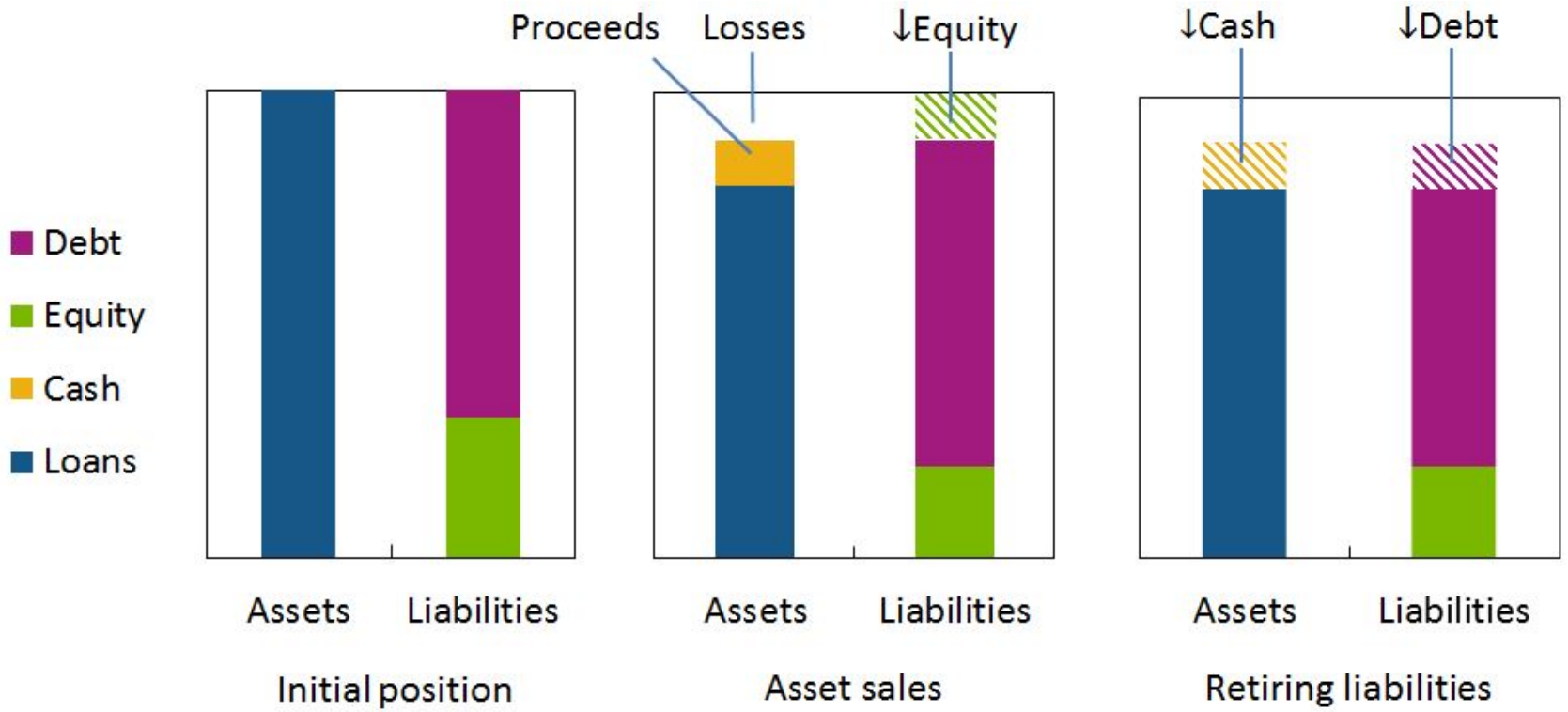

Figure: Shrinking a bank's balance sheet

Fire-sale losses

Price evolution under fire sales

$$P_{t+1}^k = P_t^k \left(1 - \delta_k^{-1} \sum_{i=1}^{N} S_t^{i,k}\right),$$

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Two forms of loss:

- Mark-to-market losses

$$\sum_{k=1}^{K} \underbrace{\left(M_t^{i,k} - S_t^{i,k}\right)}_{\text{Remaining holdings}} \times \underbrace{\delta_k^{-1} \sum_{i=1}^{N} S_t^{i,k}}_{\text{Price impact (above)}} .$$

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- Implementation shortfall

$$\frac{1}{2} \sum_{k=1}^{K} S_t^{i,k} \sum_{j=1}^{N} \delta_k^{-1} S_t^{j,k}.$$

Bank optimisation problem: Minimize liquidation losses

$$\min_{\mathbf{S^i},\mathbf{R^i}} (M^i - \frac{1}{2} S^i)^\top (\frac{S^i}{\delta}),$$

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subject to the constraints

$$\begin{aligned} CAP^i(A, E; \mathbf{S}) &\geq REG_{CAP} \\ LEV^i(A, C, E; \mathbf{S}, \mathbf{R}) &\geq REG_{LEV} \\ LCR^i(A, C, L; \mathbf{S}, \mathbf{R}) &\geq REG_{LCR} \\ CASH^i(A, C; \mathbf{S}, \mathbf{R}) &\geq 0. \end{aligned}$$

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Note: banks only internalise the effects of their own sales, and not the spillover effects of sales by other banks.

Calibration

- **Balance sheet data** taken from regulatory returns (COREP and FINREP) and Bank of England stress test data.
- **Regulatory weights** based on Basel guidance, European legislation and firms' annual statements.
- **Regulatory ratios & constraints** taken from regulatory returns.
- **Market depths** based on national authorities' published statistics on average trading volumes and S&P price indices for government bonds, and BoAML prices and oustanding volumes for corporate bonds.

Stress scenarios

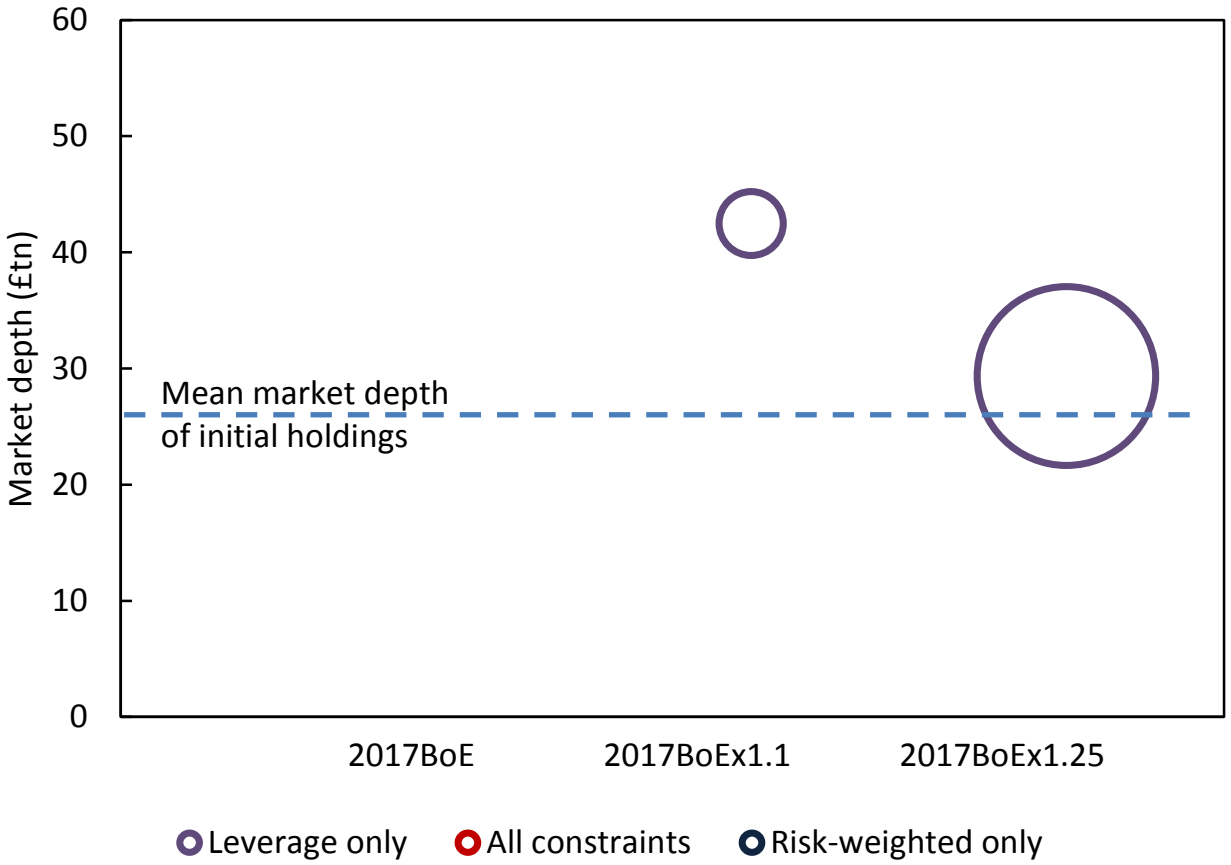
We consider three scenarios:

1. Asset shock (ϵ_A): Bank of England 2017 Stress scenario and shocks of increased intensity.
2. Funding shock (ϵ_L): Depositor run (20%, 40% and 60% deposit outflows).
3. Combined asset and funding shock: Bank of England 2017 Stress scenario and 20% deposits outflows.

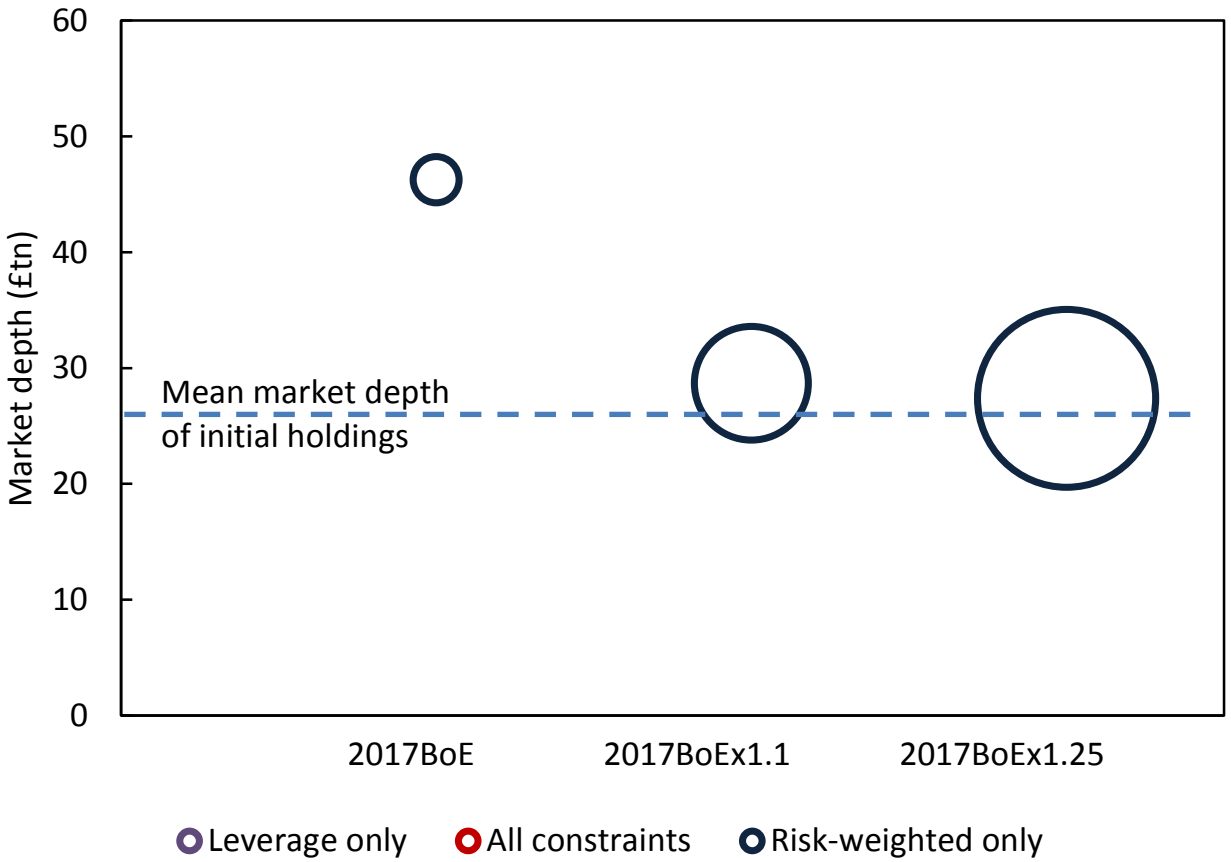
Asset shock

- Risk-weighted capital requirements tend to be more tightly binding than leverage constraints.
- Banks constrained by risk-weighted capital constraints sell on average more illiquid assets, and in larger amounts, than when constrained by the leverage ratio.
- The size of unexpected losses, which are not internalized by banks, can be as important as the size of expected losses.

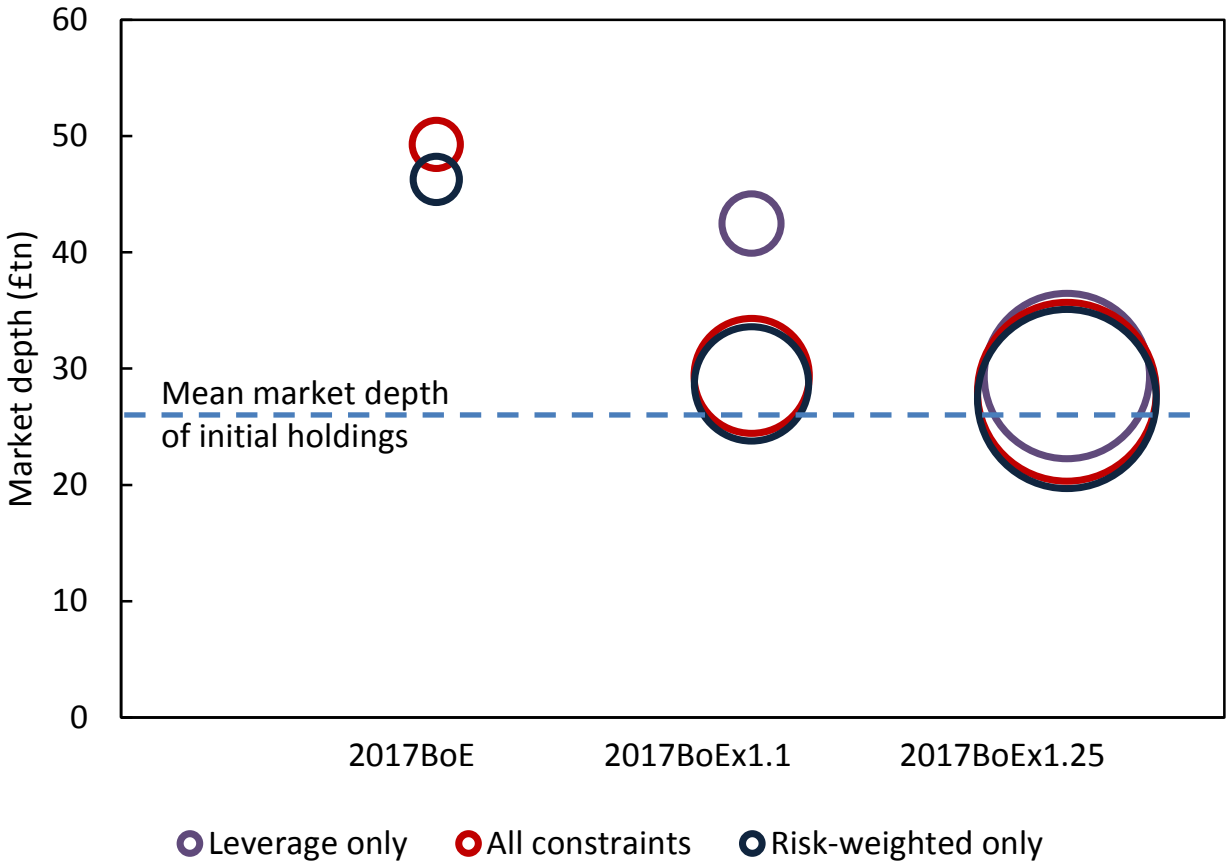
Asset sales: leverage ratio only



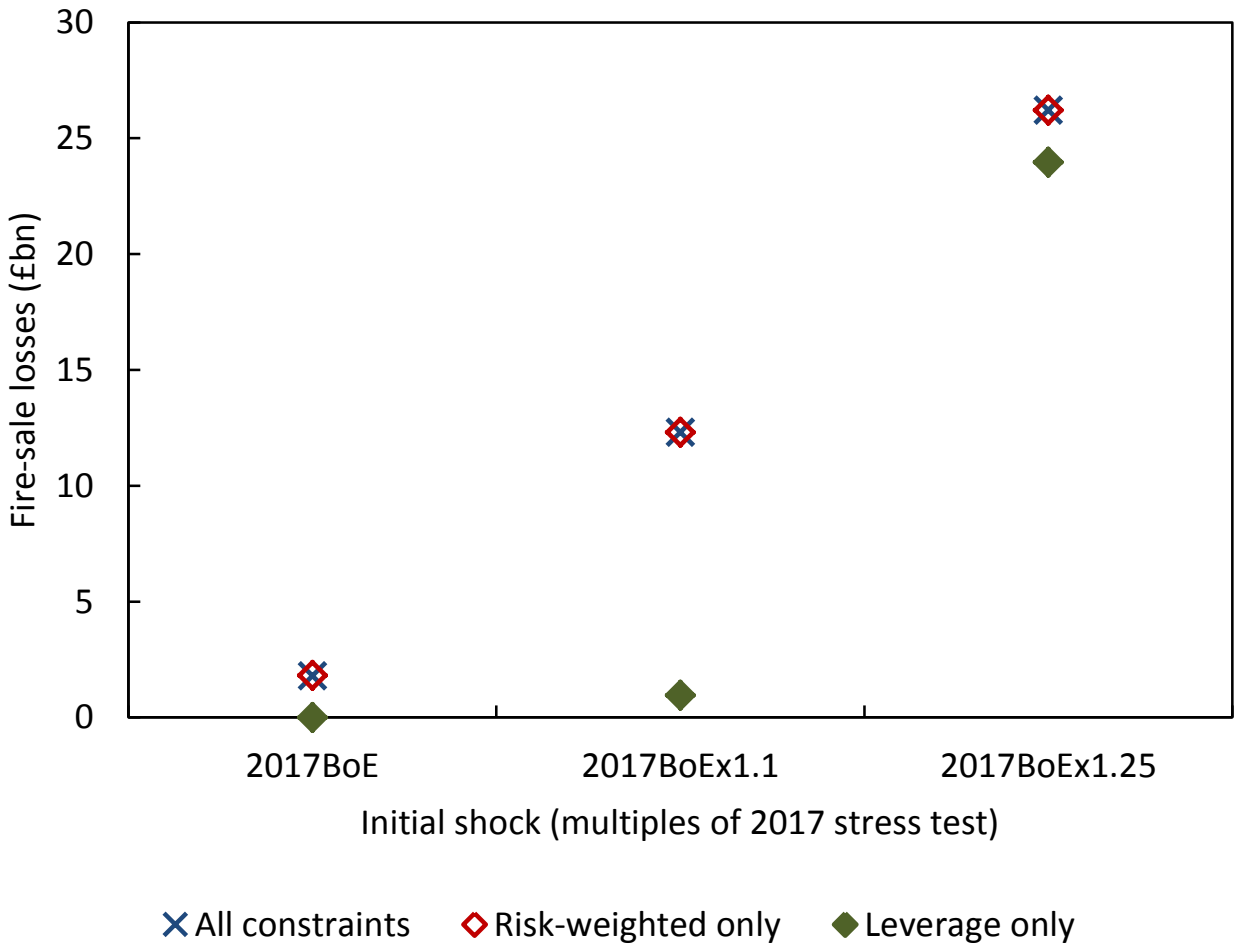
Asset sales: capital ratio only



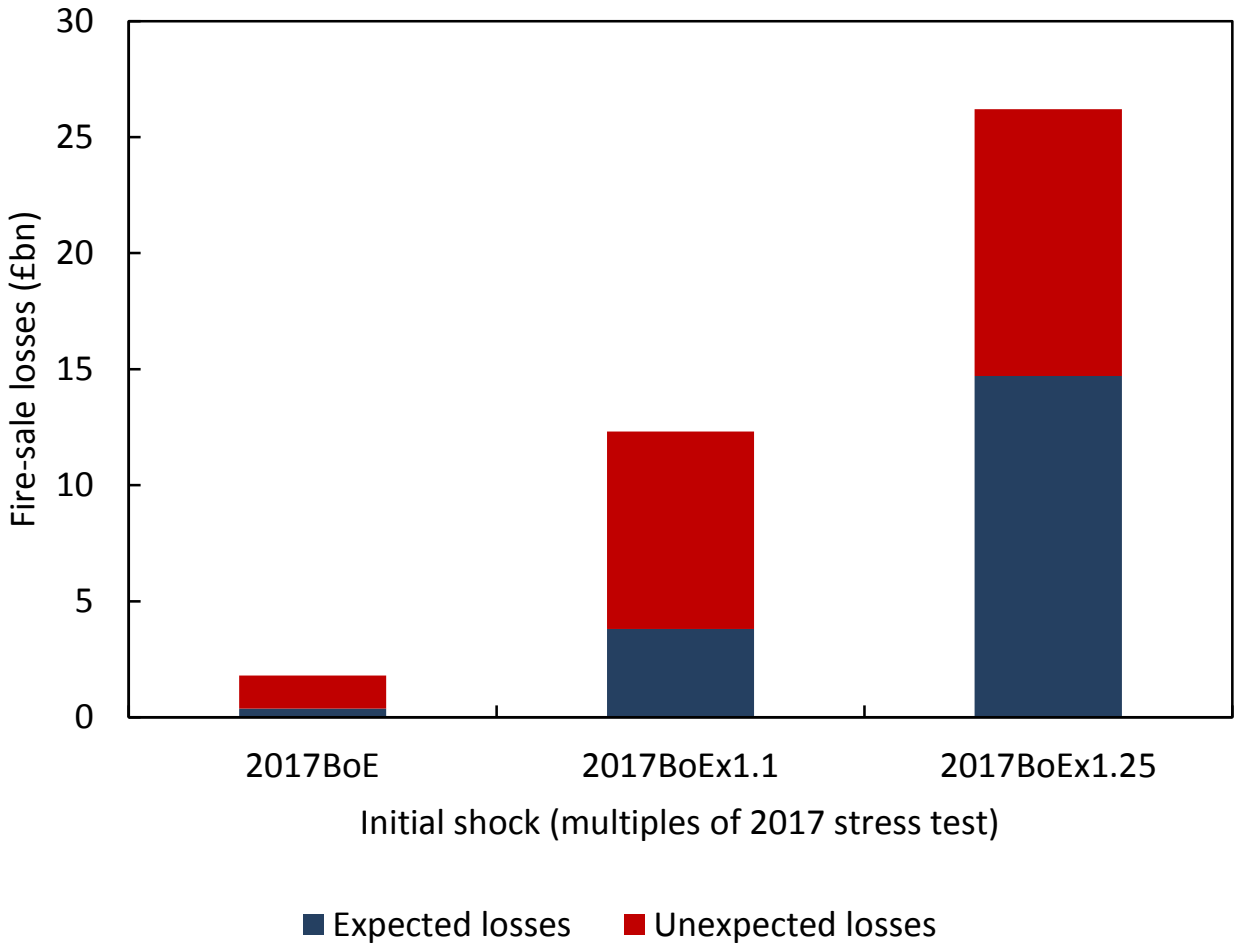
Asset sales: all constraints



Fire-sale losses



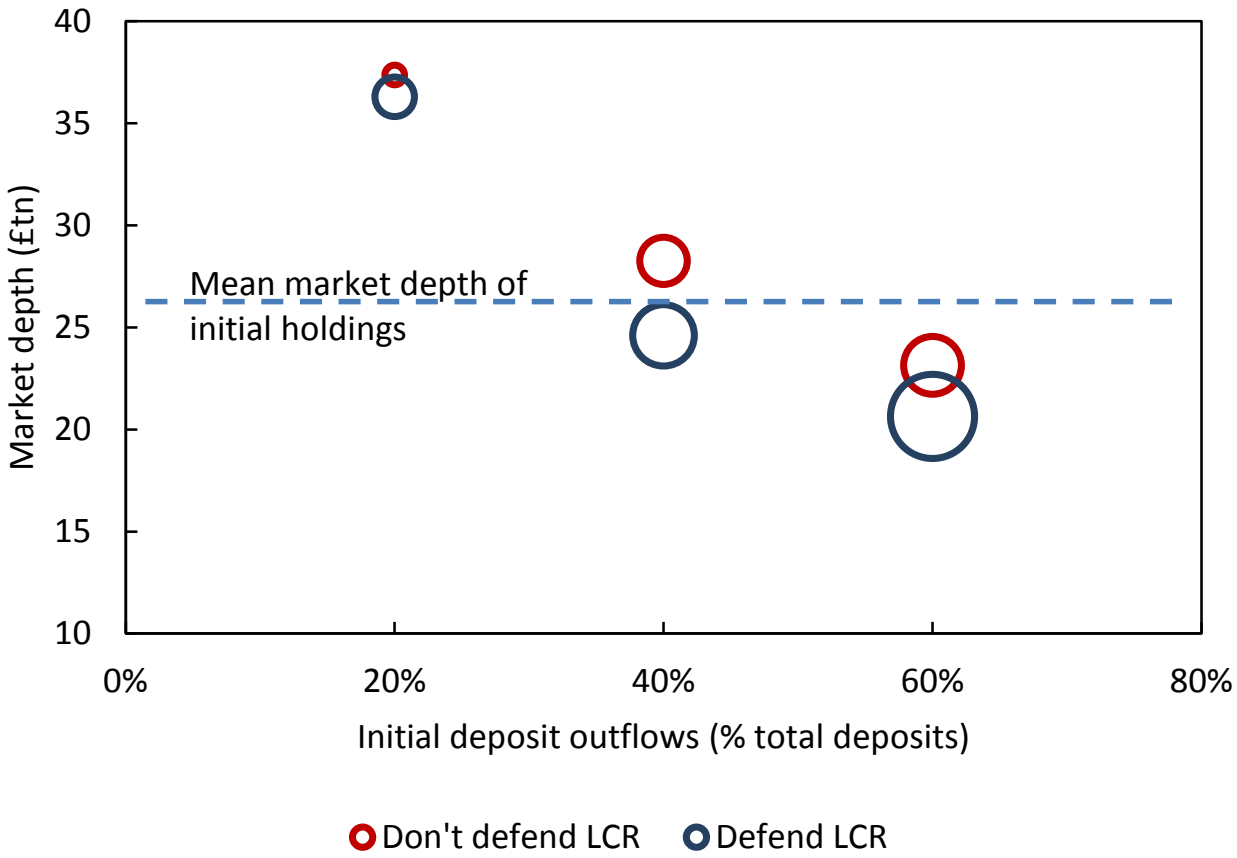
Fire-sale losses: decomposition



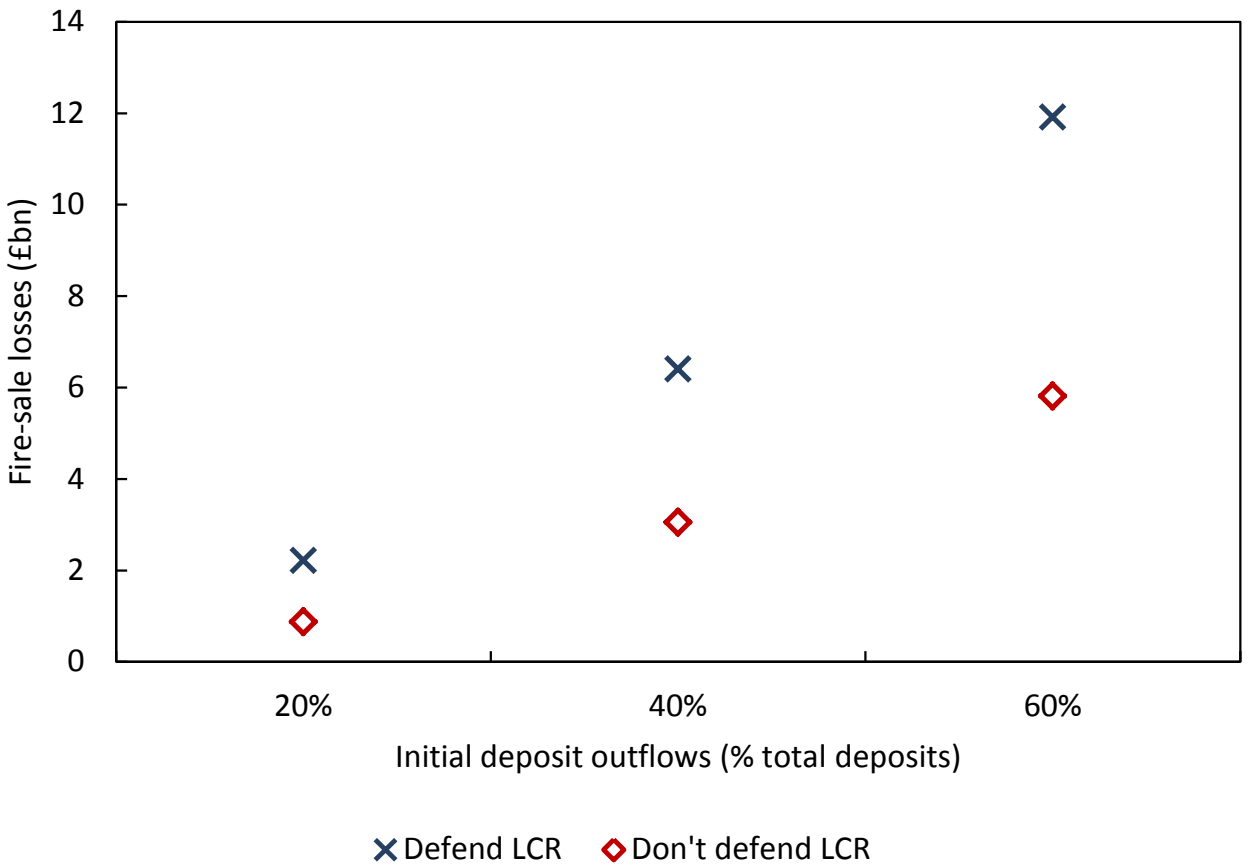
Funding shock: deposit outflows

- Banks prefer to use cash and sell highly liquid assets first to minimise losses.
- However, as the shock becomes larger, banks are forced to sell less liquid assets.
- When banks defend their LCRs to keep them above 100%, they need to sell less liquid assets in larger amounts.
- Hence fire-sale losses are significantly larger relative to the case when banks do not defend their LCRs.

Asset sales


40
35
30
25
20
15
10
Market depth (£tn)
Mean market depth of initial holdings
0%
20%
40%
60%
80%
Initial deposit outflows (% total deposits)
Don't defend LCR
Defend LCR

Fire-sale losses



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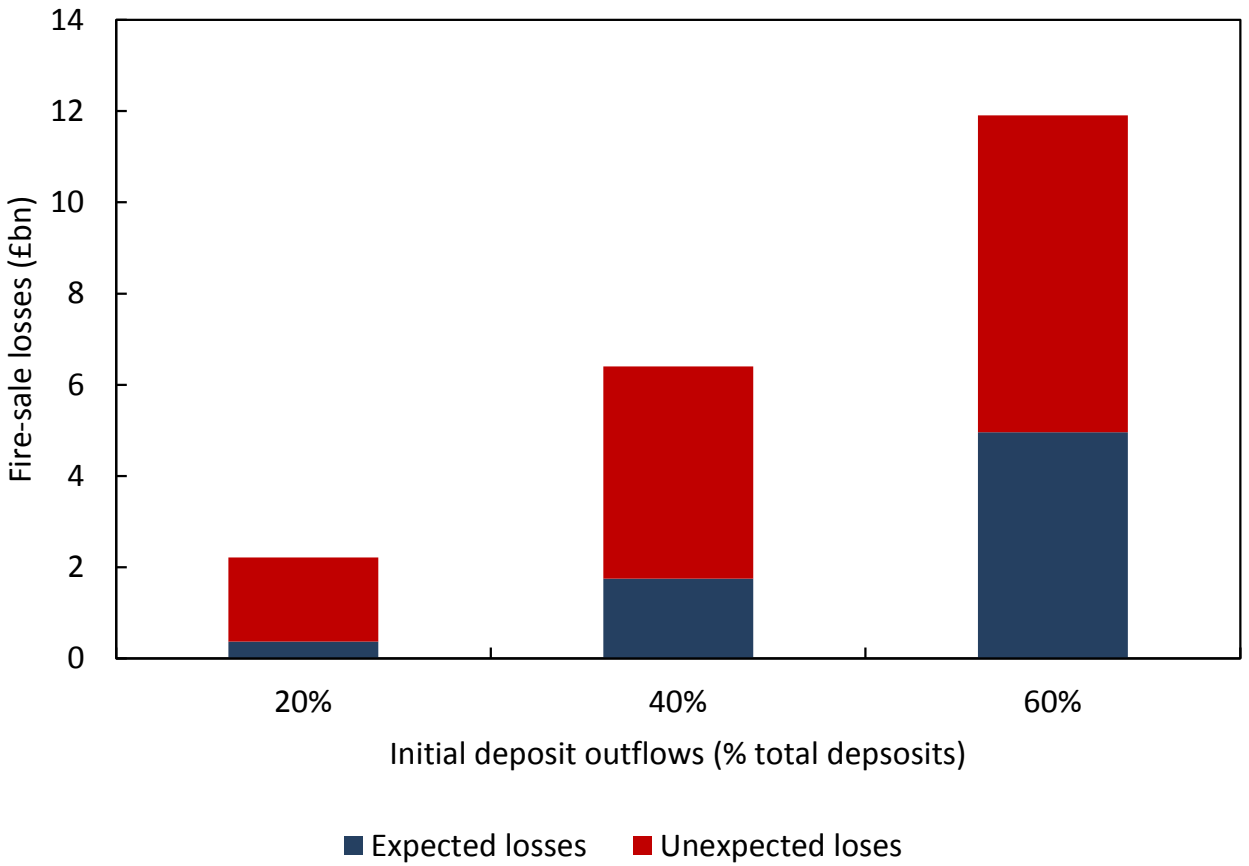
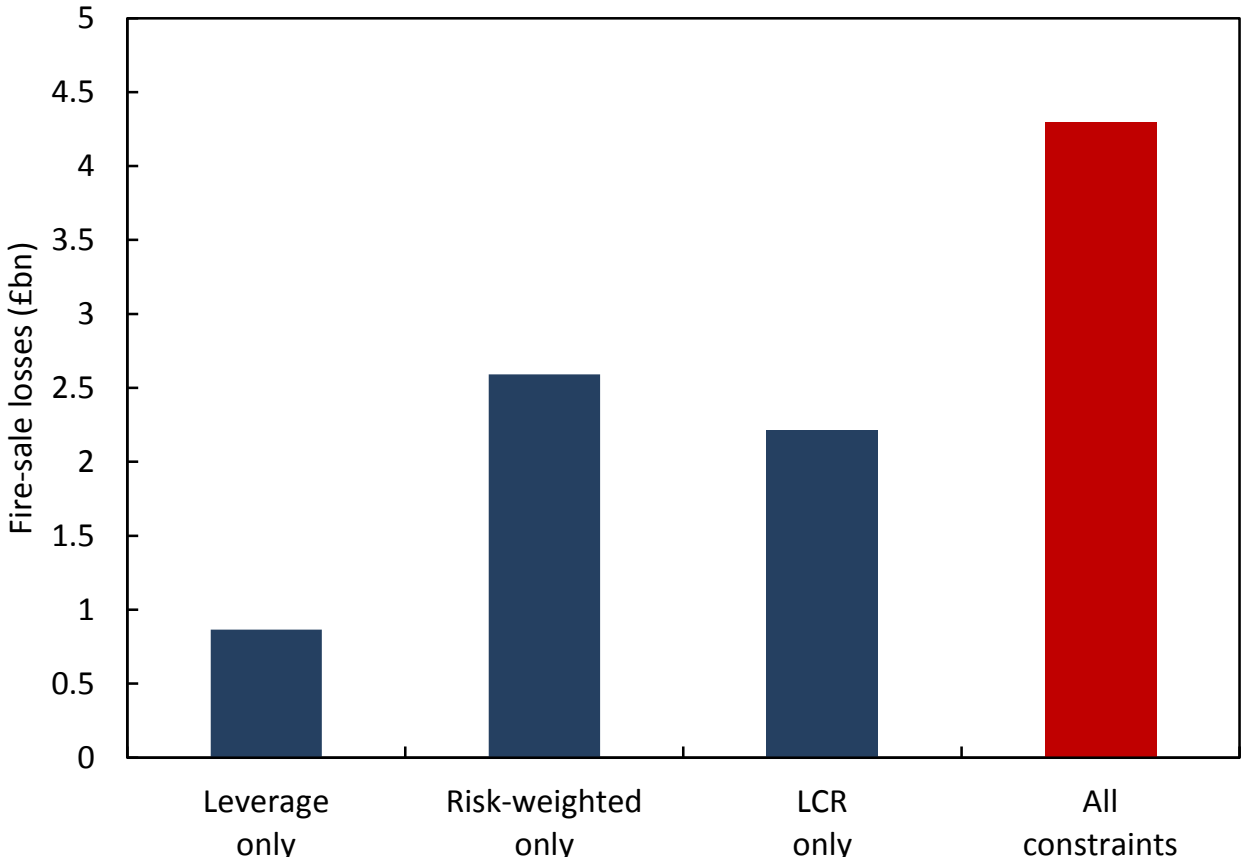


Asset and Funding shocks



Conclusions

- Both risk-weighted capital and liquidity constraints can become binding and generate significant fire sales losses, by incentivising sales of larger amounts of less liquid assets.
- Models that only account for a leverage constraint might then under-estimate fire sale losses.

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- Both risk-weighted capital and liquidity constraints can become binding and generate significant fire sales losses, by incentivising sales of larger amounts of less liquid assets.
- Models that only account for a leverage constraint might then under-estimate fire sale losses.
- Unexpected fire sales losses, e.g. losses due to deleveraging by other banks, can be larger than banks' expected losses from their own sales.
- Relaxing banks' regulatory constraints during stress may be a possible mitigating action to avoid fire sales. For example, allowing banks to draw down their LCR.

Next steps

- Run more rounds of fire sales.
- Explore solvency-liquidity nexus by running asset and funding shocks (both at the same time and sequentially).
- Sensitivity analysis: market depths, price function, targeting vs threshold.
- Constraints: UK leverage framework, LCR with limits to reserves usability.

Thank you

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