BANK OF ENGLAND

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The decline of solvency contagion risk

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Info

- Any views expressed are solely those of author(s) and so cannot be taken to represent those of the Bank of England or to state Bank of England policy.
- More details on the Bank of England Staff Working Paper: https://ssrn.com/abstract=2996689
- Run solvency contagion on your own data! https://github.com/marcobardoscia/neva

Motivation

- One of the channels through which systemic risk spreads.
- Classic critique: there have been few cascades of default.
- However, pre-default losses matter:

> *“Roughly two thirds of the losses attributed to counterparty credit risk were due to CVA losses and only about one third were due to actual default.”*[1]

- Banks mark their interbank assets to market pricing in the probability of default of their counterparty.
- Pre-default losses are a consequence of some ex-ante uncertainty.

[1]Basel Committee, 2011. http://www.bis.org/press/p110601.htm

Summary

- We extend a model of pre-default solvency contagion to the case in which bank can default at any point in time.
- We apply the model to UK data and we show that the risk associated to solvency contagion has sharply declined from the peak of the crisis.
- We decompose this fall into two main contribution: exposures and capital.

Short review

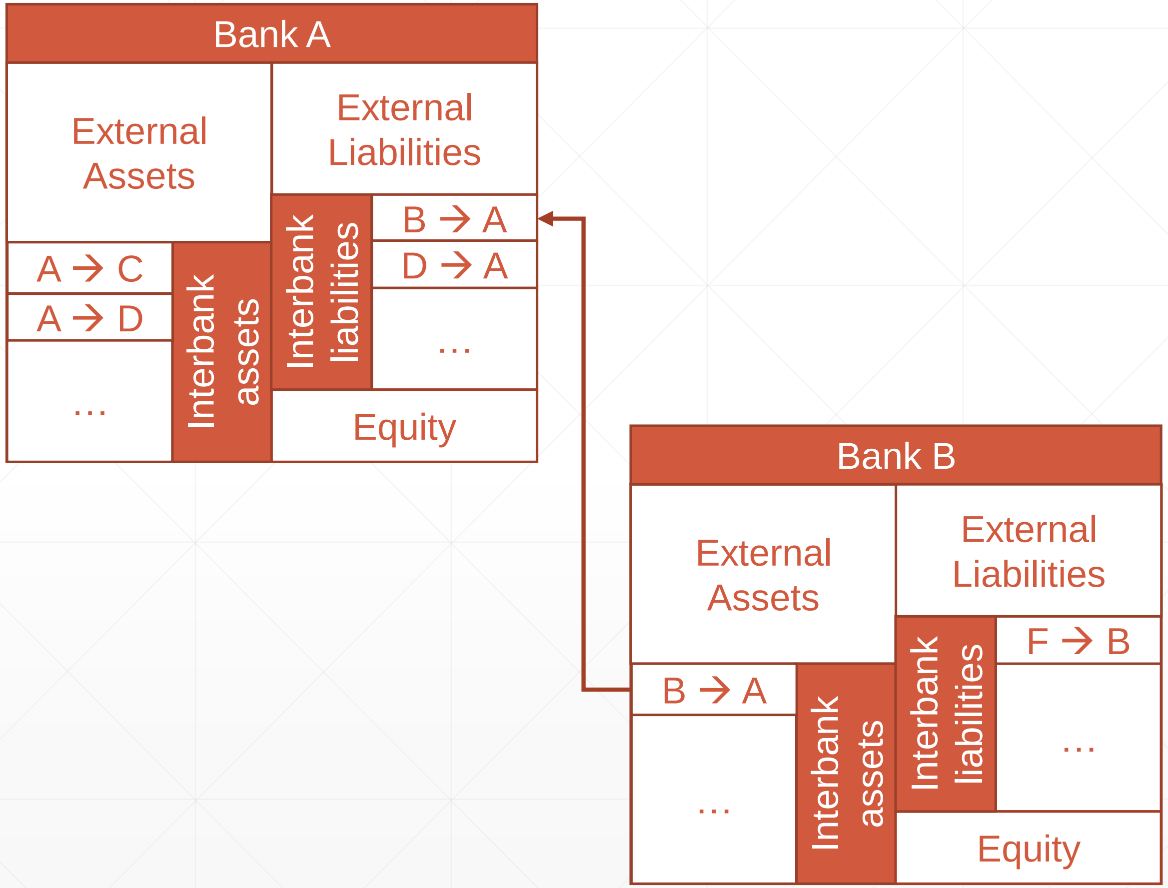
- Most empirical papers[1] are based on a simple mechanism: when a bank defaults its creditors lose the full amount of their exposures towards the defaulted bank, recovery rate is zero.
- Eisenberg and Noe[2]: recovery rate to claims towards defaulted banks is endogenously determined, and in general larger than zero.
- EN + Monte Carlo can be used for pre-default contagion[3], but it is not clear how to do it if banks can default at any point in time.
- We use the Neva framework[4] based on valuation functions.

[1]Furfine, JBCM 2003; Upper and Worms, EER 2004; Wells, BoE SWP 2004; Degryse et al, IJCB 2007; Cont et al, 2010; Mistrulli, JBF 2011.
[2]Eisenberg and Noe, MS 2001.
[3]Elsinger et al, MS 2006; Elsinger et al, IJCB 2006.
[4]Barucca et al, SSRN 2016.

Model

- Asset side:
  - External assets (e.g. loans)
  - Interbank assets
- Liability side:
  - External liabilities (e.g. deposits)
  - Interbank liabilities
  - Equity
- Balance sheet identity:

$$A_i^e + \sum_{j=1}^{n} A_{ij} = L_i^e + \sum_{j=1}^{n} L_{ij} + E_i$$



Valuation functions: Before maturity

- We perform a risk-neutral valuation of interbank claims at time $t < T$. The price of assets is computed as an average over the risk-neutral measure:

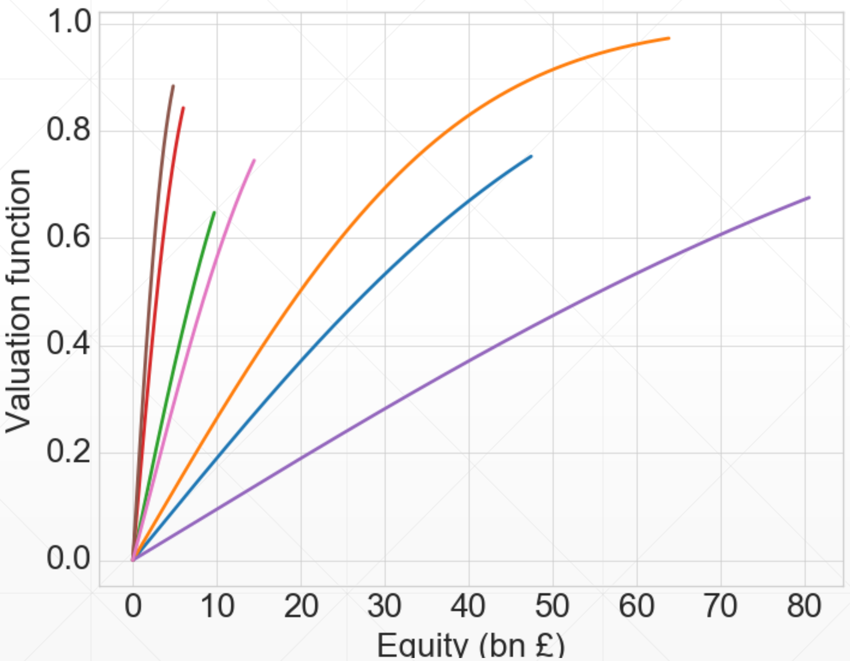
$$E_i(t) = A_i^e(t) + \sum_{j=1}^{n} A_{ij} \mathbb{E}^{\mathbb{Q}} \left[\mathbb{V}_{ij}(E_j(T); \ldots) | \mathbf{A}^e(t) \right] - L_i^e - \sum_{j=1}^{n} L_{ij}$$

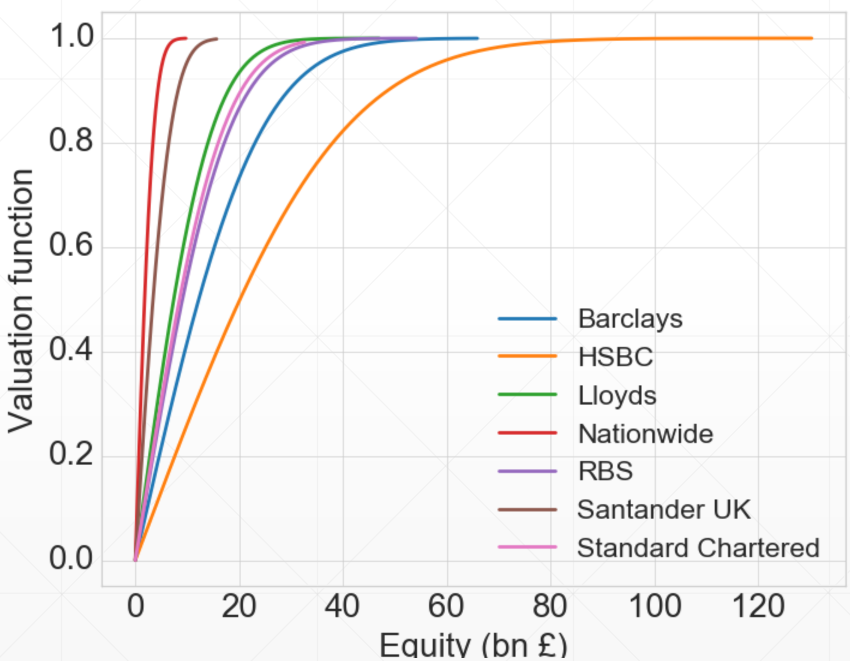
- The valuation of interbank assets is performed via a discount factor that incorporates the probability of default of the counterparty:

$$\mathbb{E}^{\mathbb{Q}} \left[\mathbb{V}_{ij}(E_j(T); \ldots) | \mathbf{A}^e(t) \right] = 1 - p_j^D(E_j(t)) + \rho\, p_j^D(E_j(t))$$

- Banks can default at any time before the maturity (a la Black and Cox).

Valuation functions: Calibration





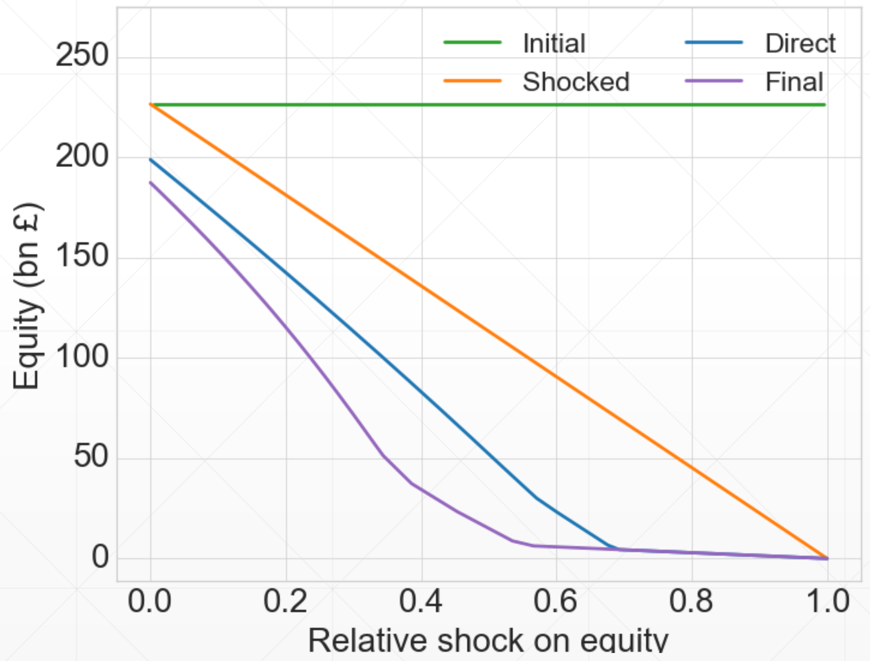
2008 (left) and 2015 (right), recovery rate = 0

Data

- We use real interbank exposures between banks part of the Bank of England's annual concurrent stress test:
  - 7 banks, which account for 80% of the regulated UK lending
  - 2008 – 2013: exposures larger than 10% of equity
  - 2014 – 2015: no threshold, more granular data
- When possible (2013 – 2015) we interpret the equity of our model as the CET1 buffer, otherwise we use shareholders' equity for consistency.
- Volatilities are estimated from returns of banks' stock prices.

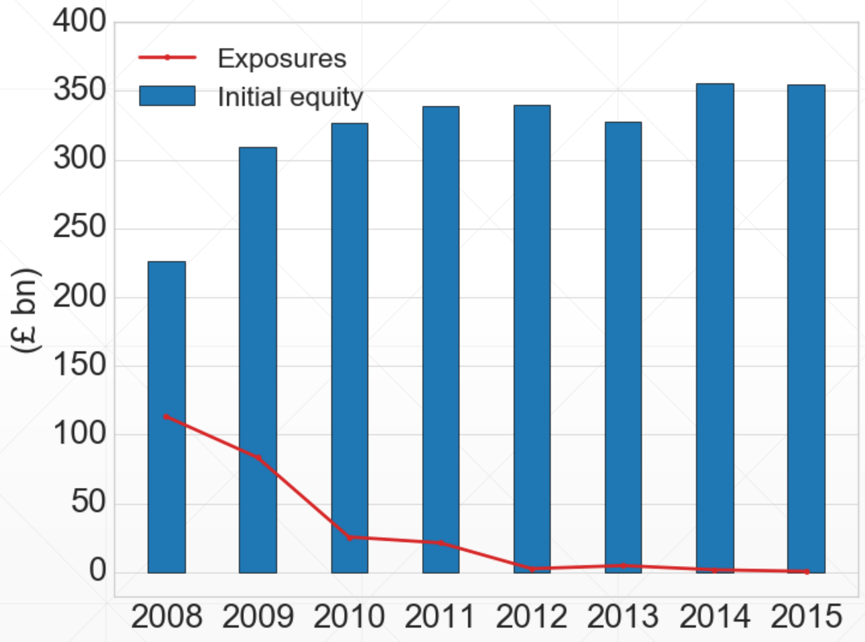
Simplified stress tests

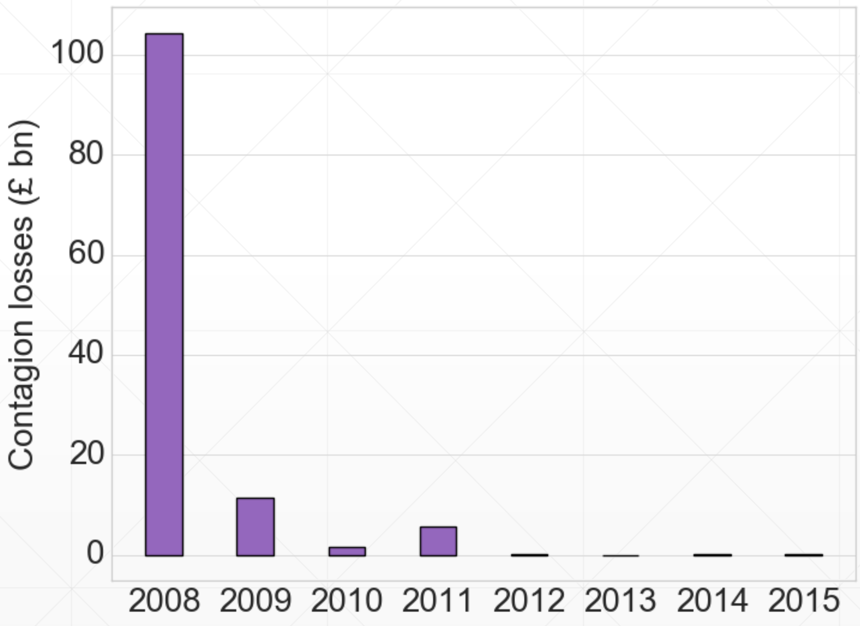
- We run simplified stress tests. In the first “scenario” all banks suffer a homogeneous (relative) shock to their equity.
- Losses due to contagion (orange to purple) can be as large as the exogenous shock.
- Losses caused by direct exposures (orange to blue) can be a large as those caused by indirect exposures (blue to purple).



2008, recovery rate = 0

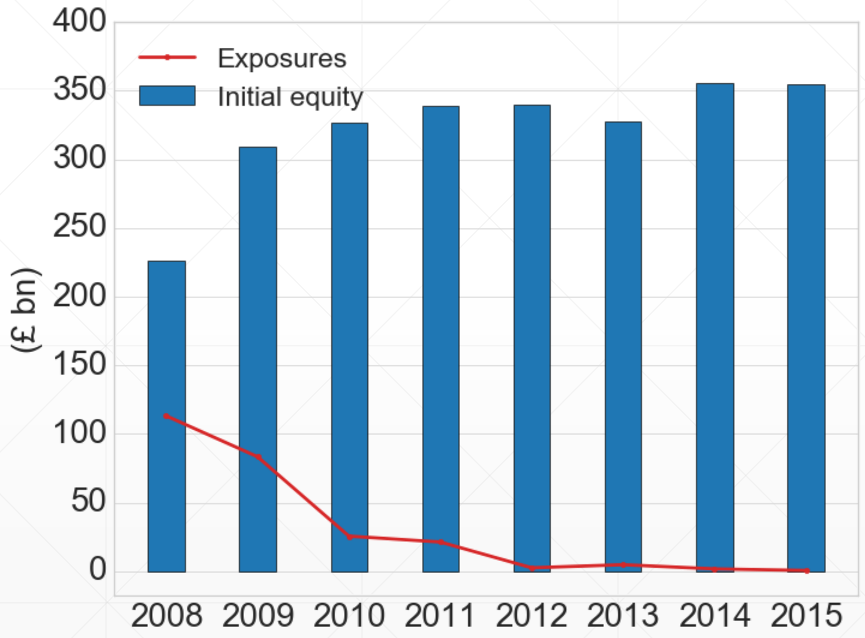
Contagion losses decline





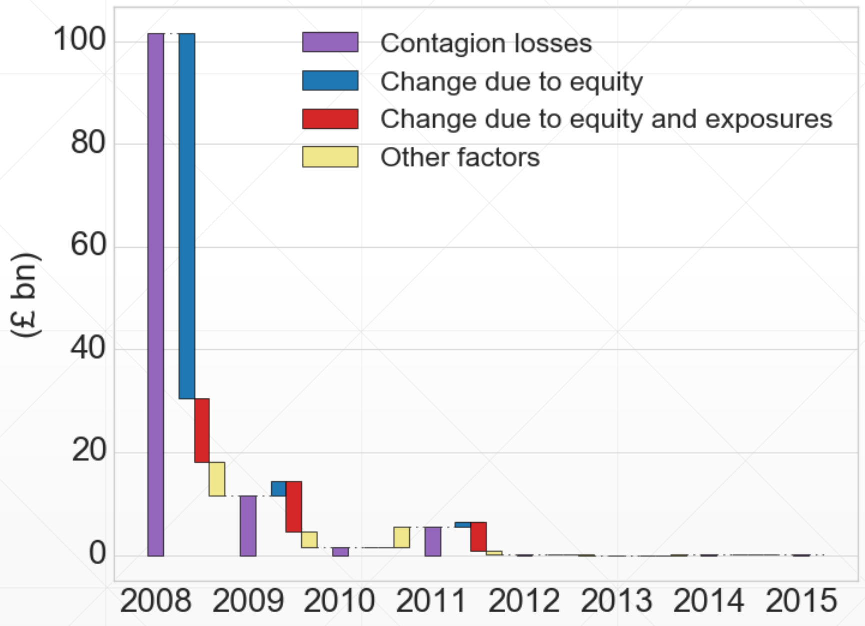
Shock on equity = 40%, recovery rate = 0

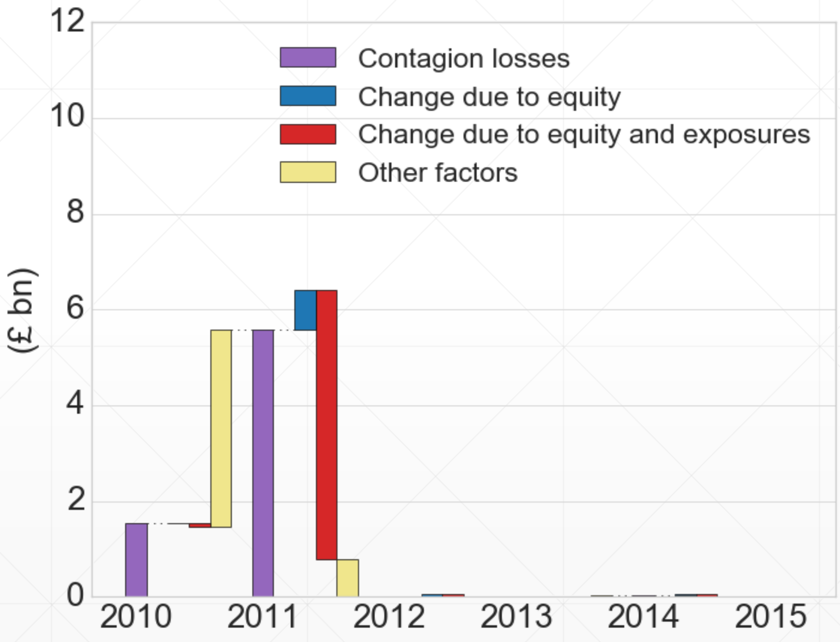
Decomposing the fall



- In order to isolate the effect in changes of equity and exposures we build synthetic balance sheets:
  1. 2008 balance sheets with 2009 equity,
  2. 2008 balance sheets with 2009 equity and exposures,
- As a robustness check we also do vice versa.

Decomposing the fall





Shock on equity = 40%, recovery rate = 0

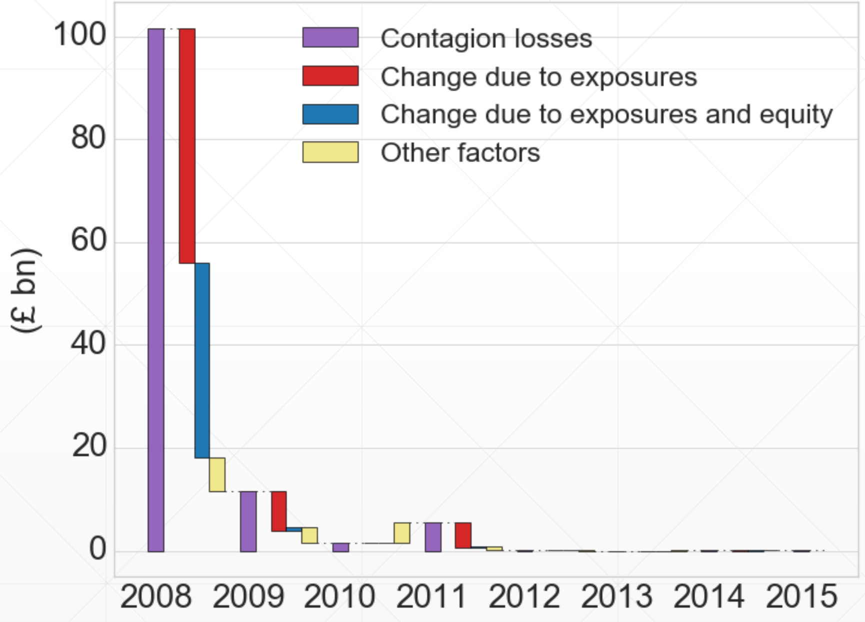
A more realistic scenario

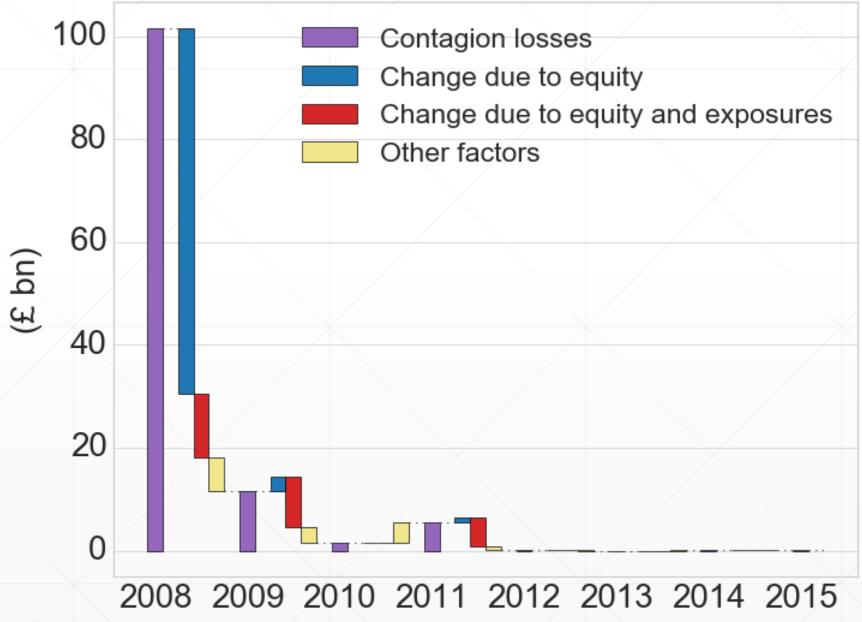
- We also run a more realistic “scenario” in which our model is used as a macro-prudential “overlay” to the Bank of England’s annual concurrent stress test.
- In 2014, 2015, and 2016 we take the CET1 buffer at the point in time in which banks are most vulnerable (in terms of the CET1 to risk-weighted assets ratio) as the post-shock equity of our model.
- By setting the recovery rate equal to zero we get the following contagion losses:
  - 2013: £0bn
  - 2014: £0.2bn
  - 2015: £0.02bn

Conclusions

- The risk related to solvency contagion has shapely decreased from the peak of the crisis to today.
- We decompose the fall into two main drivers, equity and exposures.
- The distribution of equity matters: the contribution to contagion losses due to equity increases, even when capital in aggregate increases or stays constant.

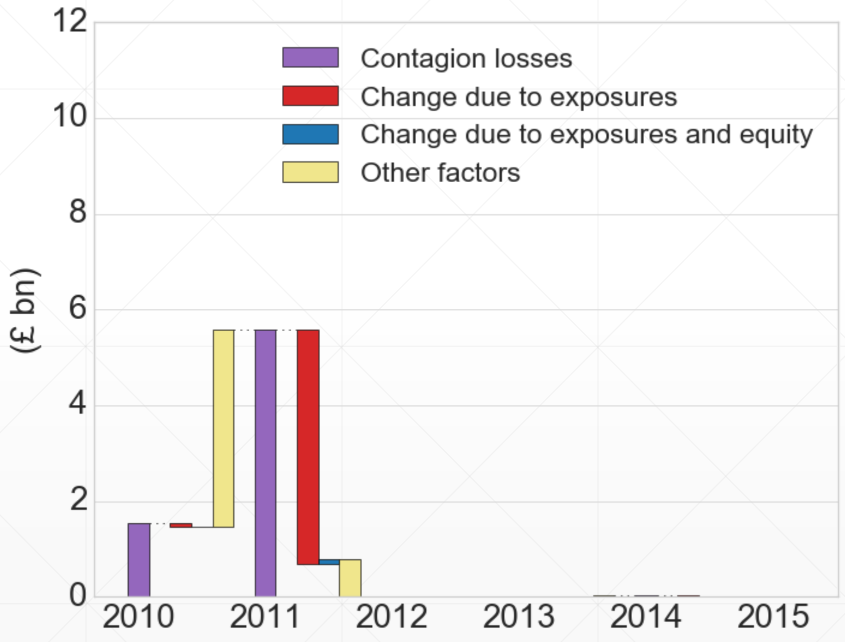
Decomposing the fall

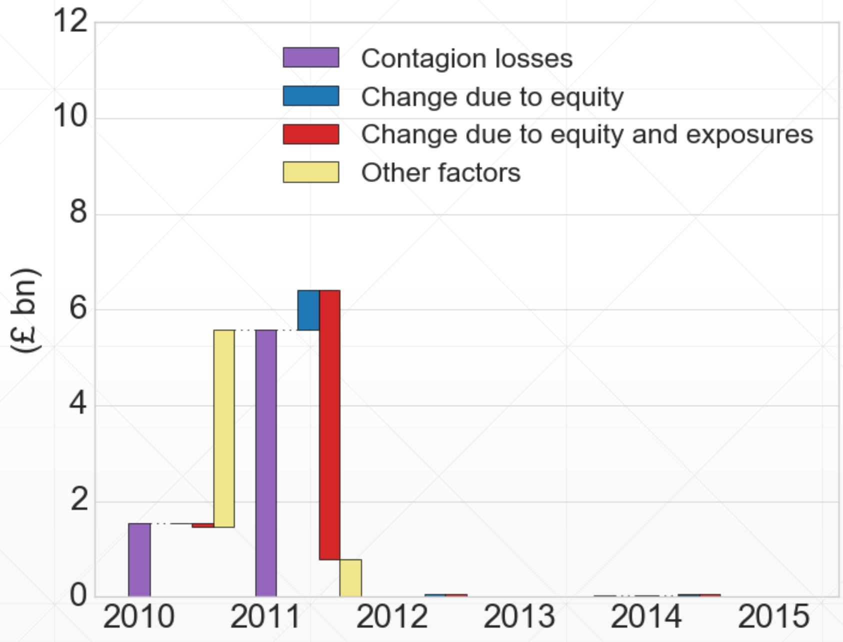




Shock on equity = 40%, recovery rate = 0

Decomposing the fall: Zooming in





Shock on equity = 40%, recovery rate = 0

Valuation functions: At maturity

- We take external assets at their market value, while liabilities do not change:

$$E_i(T) = A_i^e(T) + \sum_{j=1}^{n} A_{ij} \mathbb{V}_{ij}(E_j(T); \dots) - L_i^e - \sum_{j=1}^{n} L_{ij}$$

- The valuation of interbank assets is performed via a discount factor:

$$\mathbb{V}_{ij}(E_j(T); \dots) = \begin{cases} 1 & \text{for } E_j(T) > 0 \\ r_j(E_j(T); \dots) & \text{for } E_j(T) \leq 0 \end{cases}$$

  If the borrower has not defaulted, then the discount factor is equal to one and the interbank asset is worth its face value; otherwise it will be worth less.

Valuation functions: Before maturity

- We now perform a risk-neutral valuation at time $t < T$. The price of the assets is computed as an average over the risk-neutral measure:

$$E_i(t) = A_i^e(t) + \sum_{j=1}^{n} A_{ij}\mathbb{E}^{\mathbb{Q}}\left[\mathbb{V}_{ij}(E_j(T);\ldots)|\mathbf{A}^e(t)\right] - L_i^e - \sum_{j=1}^{n} L_{ij}$$

- Let's make a wild guess (assuming that we know the probabilities of default):

$$\mathbb{E}^{\mathbb{Q}}\left[\mathbb{V}_{ij}(E_j(T);\ldots)|\mathbf{A}^e(t)\right] = 1 - p_j^D(E_j(t))$$

- A slightly more sophisticated guess:

$$\mathbb{E}^{\mathbb{Q}}\left[\mathbb{V}_{ij}(E_j(T);\ldots)|\mathbf{A}^e(t)\right] = 1 - p_j^D(E_j(t)) + \rho\, p_j^D(E_j(t))$$

Valuation functions: Theorems

- We have a system of *n* non-linear equations, equities are the unknown.
- In Barucca et al. (2016) (under mild assumptions) it is shown that the equations to compute the equities have a greatest solution, i.e. a solution that is simultaneously optimal for all banks.
- In order to compute the greatest solution one simply has to iterate the equations for equities using the book value of equities as a starting point.
- In order to compute the losses due to a shock:
  1. Use post-shock equities as a starting point
  2. Find the fixed-point of the equations for equities