Fire-sale modelling

Cifuentes, Ferrucci, and Shin (2005),
Landier, Greenwood, and Thesmar (2015)

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Cifuentes, Ferrucci, and Shin (2005), "Liquidity risk and contagion", JEEA

Cifuentes, Ferrucci, and Shin (2005)

Liquidity risk and contagion

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Literature

What is systemic risk?

Network view

- Systemic risk from 'within' the financial system
- *Interconnected* relationships between institutions forming financial networks
- Give rise to amplification effects that destabilise the system

Research questions

- How do we measure and quantify systemic risk?
  - $\rightarrow$ How to identify and model amplification mechanisms in financial networks?
- Are there different *channels* of systemic risk?

Channels of systemic risk[1]

1) Direct amplification effects

- Occur between financial institutions in networks of bilateral contractual obligations
- Interbank default contagion:
  One financial institution defaults on its interbank liabilities
  $\rightarrow$ adversely impacts the balance sheet of another financial institution
  $\rightarrow$ triggers further losses $\rightarrow$ *cascades of defaults*

- Eisenberg and Noe (2001): Standard framework for quantifying systemic losses from default contagion

- Large literature on the role of network structure e.g. Gai et al. (2011), Acemoglu et al. (2015), Allen et al. (2010)

[1] Brunnermeier and Oehmke (2013)

Channels of systemic risk cont.

2) Indirect amplification effects[2]

- Common asset holdings amongst financial institutions
- Similar exposure in assets can lead to self-reinforcing liquidation spirals like *fire-sales* in times of stress
    - Fire-sale externalities are pecuniary externalities that operate through prices
    - Distressed banks want to cover their losses, "dump" their assets on the market and depresses prices

$\rightarrow$ How to model these feedback-effects?

[2] Shleifer and Vishny (2011)

Paper 1 - Cifuentes et al. (2005)

Cifuentes, Ferrucci, Shin (2005),

"Liquidity Risk and Contagion", *European Economic Association*

Theroetical simulation model
incorporating default contagion and
fire-sale externalities

Contribution

How did the paper help understand systemic risk?

- Presents a framework which studies both direct and indirect amplification effects by modelling default contagion and fire-sale externalities
- Endogenises buying and selling of an illiquid asset at equilibrium fire-sale price

Framework overview

Model for a financial sector

- Exogenous shock: Bank default triggers asset write-downs across system $\rightarrow$ this can violate other banks' capital requirement
- Re-sizing: A quantity s of the illiquid asset is sold by over-sized or insolvent banks $\rightarrow$ Given s, a new price of the illiquid asset is determined by a demand function
- Re-prizing: Mark-to-market accounting leads to re-pricing of illiquid asset by all nodes in the system $\rightarrow$ Check: Are all banks solvent under the new price?
- If there is at least one insolvent bank, the algorithm is iterated again until an equilibrium is found where all banks satisfy the solvency condition

Model

Model set up (1)

N	Interlinked banks
T	Periods
c_i	Liquid asset
e_i	Illiquid asset with price p
x_i	Market value of bank i's total interbank liabilities
$\pi_{ij} = \frac{L_{ij}}{\sum_j L_{ij}}$	Fraction i ows j given its total notional liability amount
$\bar{x} = \sum_j L_{ij}$	the notional amount of bank i's total interbank liabilities
r	Capital adequacy ratio
$x_i \pi_{ij}$	payment by i to j

Equity net worth of bank i:

$$\underbrace{pe_i}_{\text{illiquid asset}} + \underbrace{c_i}_{\text{liquid asset}} + \underbrace{\sum_j x_j \pi_{ij}}_{\text{payments from other banks}} - \underbrace{x_i}_{\text{interbank liabilities}} \tag{1}$$

Model contin.

1) Given a price p, which bank pays what?

Determine a vector of payments between banks $x = (x_1, ..., x_i)$ with each banks' payments:

$$\bar{x}_i = min\{\bar{x}, \underbrace{pe_i + c_i}_{w(p)_i} + \sum_j x_j \pi_{ij} - x_i\} \tag{2}$$

i.e. the minimum between the notional debt amount and its net equity worth

In vector form:

$$x = \bar{x} \wedge (w(p) + \Pi_x^T) \tag{3}$$

where $w(p) = (w_1(p), ..., w_n(p))$, Π_x^T is the transpose of the exposure matrix, $\wedge$ the pointwise minimum operator vector

Model contin.

The clearing vector x that satisfies (3) is a fixed point of the mapping:

$$H(x) \equiv \bar{x} \wedge (w(p) + \Pi_x^T) \tag{4}$$

- $H(x)$ is an increasing function of the lattice $\mathbb{R}^n_+$, with infimum defined by theoperator $\wedge$

- $H(0) \geq 0$ and $H(x) \leq \bar{x}$

  $\rightarrow$ Tarski's fixed point theorem says that there is at least one point of H(.), hence at least one clearing vector

Model contin.

Following Eisenberg and Noe (2001), we have

Lemma 1: Suppose the banking system is connected, and that at price p, there is at least one bank that has positive equity value. Then, there is a unique clearing vector x *such that*

$$x = \bar{x} \wedge (w(p) + \Pi_x^T) \tag{5}$$

and $x(p)$ is the unique clearing vector when the price of the illiquid asset is given by p.

This means that each payemnt x_{ij} can be determined as a function of p and accoring to the pro-rata rule $x_i \pi_{ij} = x_i \frac{L_{ij}}{\sum_j L_{ij}}$

Model contin.

2) Capital adequacy ratio

Banks have to hold a minimum level of capital for their assets, i.e.

$$\frac{pe_i + c_i + \sum_j x_j \pi_{ji} - x_i}{p(e_i - s_i) + (c_i - t_i) + \sum_j x_j \pi_{ji}} \geq r* \qquad (6)$$

t_i	units of liquid assets sold
s_i	units of illiquid assets sold
numerator	equity value of the bank given interbank claims and liabilities in terms of realized payments
denominator	mark-to-market value of its assets after the sale of assets are sold for cash

Model contin.

Assumption:

1. $s_i > 0,$ only if $t_i = c_i$, i.e. banks sell all liquid assets before selling its illiquid assets
2. $p = e^{-\alpha(\sum_i s_i)}$

Equilibrium

In equilibrium, the vector of payments x, sales of the illiquid asset s and price p of the illiquid asset (x, s, p) is such that:

- For all banks $i, x_i = min\{pe_i + c_i + \sum_j x_j \pi_{ji} - x_i\}$
- For all banks i, s_i is the smallest sale that ensures that $r*$ is satisfied. If there is no value of $s_i \in [0, e_i]$ for which the capital adequacy condition is satisfied, then $s_i = e_i$
- There is a downward sloping inverse demand function $d^{-1}(.)$ such that $p = d^{-1} \sum_i s_i$

Model contin.

Equilibrium contin.

Rearranging capital adequacy ratio (6) and because $s_i > 0,$ only if $t_i = c_i$ yields

$$s_i = \begin{cases} 0 \\ \min\{e_i, \frac{x_i - (1-r^*)(\sum_j x_j \pi_{ji} + pe_i) - c_i}{r^* p}\} \end{cases}$$

Since interbank payment x_{ij} are all a function of p, sales $s_i(p)$ are also a function of the price

-

$$s = \sum_i s_i(p)$$

is the **aggregate supply** which is decreasing in p

- Further assume $p = e^{-\alpha(\sum_i s_i)}$ as **inverse demand curve** for the illiquid asset where α is a positive constant

In equilibrium

$$s(p) = d(p)$$

Model contin.

The equilibrium price is a fixed point of the mapping $\Phi(.)$, where Φ is a function $\Phi : [p, 1] \to [p, 1]$ as defined as

$$\Phi(p) = d^{-1}(s(p))$$

For any given price p, the value $\Phi(p)$ is the market clearing price of the illiquid asset that results when the price of the illiquid asset on the banks balance sheets are evaluated at price p

Proposition 2
If $\phi(p) \geq p$ for all p, there is a unique equilibrium in which p=1. In this case, the value of the banking system declines only by the size of the initial shock

Model contin.

Proposition 3

If $\phi(p) < p$ for some values of p, then there is an equilibrium in which p is strictly below 1, and in which there are sales of the illiquid asset

In this case, the banking system will reach this equilibrium by the step adjustment process provided that the initial shock is big enough

Model contin.

The algorithm sequence

- Check condition: Does the equity ratio of each bank satisfy (6)?
- If all banks fulfill capital requirements nothing happens
- If violated, the bank can scale down the size of its assets to a new level consistent with the level of equity capital. If this is not possible the bank is liquidated
- Liquidation also occurs if equity capital is insufficient to support more assets than the outstanding claims in the interbank market

The threshold level of equity capital for technical solvency is given by:

$$r * \sum_i L_{ij} \tag{7}$$

Model contin.

The algorithm sequence II

- Liquidation routine:
  - Both liquid and illiquid assets are sold to settle liabilities[3]
  - Defaulting bank pays all claimants in proportion of the size of their nominal claims $\rightarrow$ i.e. losses are distributed proportionally among all creditors

  - Liquid assets are sold for cash at the notional value
  - Illiquid assets have to be liquidated at market price
  - The proceeds from the sale can then be used to settle liabilities

  - Interbank assets are not cashed but redistributed at face value proportionally among the holders of the bank's liabilities who become the new creditors of the contract given by the defaulting or resizing bank

[3] according to priority of debt claims,proportionality and limited liability

Model contin.

The algorithm sequence III

- For defaulting and oversized banks the algorithm keeps track of the quantity of the illiquid asset sold in the market
- Combining this information with the demand function of the illiquid asset allows calculating the new equilibrium price of the illiquid asset
- Mark-to-market rules imply that all banks have to re-price their stock holding of illiquid assets in their balance sheet at the new (lower) market price
- The routine starts again

Model - Equilibrium

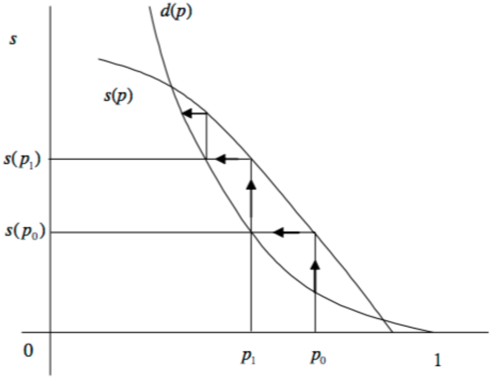

Figure 1: Amplification of shock through asset sales

Simulation

Simulation

Hypothetical banking system

- 10 banks with homogeneous balance sheets

Liquid and illiquid assets	70	Equity	7
Interbank assets	30	Deposits	63
		Interbank liabilities	30
Total assets	100	Net worth and liabilities	100

- Regulatory capital requirement: equity must be at least 7% of total assets; if equity falls below this threshold then banks would need to scale down their balance sheets
- Shock: introduce failure of one of the banks
- Contagion is measured by the number of banks that fail after the first bank is shocked

Results

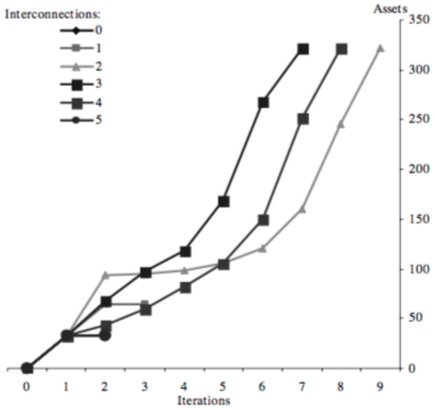

Figure 5: Total assets sold

Results

(1) Asset prices may be a powerful channel of systemic contagion

- When only considering default contagion, the system tends to be more resilient to shocks when the number of counterparts is higher[4]

- However, when the fire-sale channel is added, the fall in the price of the illiquid asset may be higher in the case of *more interconnections*
  - The endogenous process of price reduction can be of wider magnitude in the case of a higher number of counterparts

- The total number of bank failures depends on
  - the size of the initial shock
  - the elasticity of the residual demand curve

[4] This is consistent with Allen and Gale (2000) that more interconnected systems are safer

Results

(2) Liquidity holdings can help to avoid contagion

- Banks with significant holdings of liquid assets as a share of total assets
  - are generally more resilient to shocks
  - are less susceptible to contagion, as they are less exposed to fluctuations of the price of the illiquid asset and face lower credit risk
  - they create less externalities on the rest of the system, as they can settle their liabilities through the liquid asset if these banks default or have to resize $\rightarrow$ create less systemic contagion

Results: When does contagion occur?

Insolvencies at each round by number of counterparts

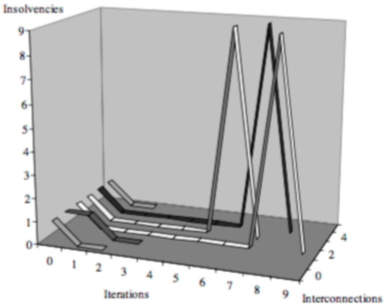

Figure 3: Failures at each iteration

One counterpart: there is only one failure in the first round

Two to four counterparts: No failures in the initial rounds. However, the process starting in the market of the illiquid asset ends up in a higher number of defaults in later rounds

Results

(3)

- More diversified interbank credit structures lead to safer system

    - The asset price channel of systemic contagion disappears when the number of interlinkages is high enough to allow banks to stand the losses without selling illiquid assets, i.e. they sell liquid assets only to adjust balance sheets

    - In their simulations, this happens when the number of counterparts is five or more

Conclusion

- Prudential regulations can have perverse effects on the stability of a financial system under certain circumstances
- The combination of mark-to-market accounting and solvency constraints have the potential to induce an endogenous response that far outweighs the initial shock
    - When assets are marked-to-market at the new prices, externally imposed solvency constraints may trigger further sales
- For a given shock, systemic resilience and bank interconnections are **non-linearly** related, i.e. more interconnected systems may also be riskier than less connected systems under some circumstances

Policy Implications

- Regulators are familiar with the potentially destabilizing effect of solvency constraints in distressed markets

- Asset price contagion by itself cannot be used to argue against prudential regulations and transparency for two reasons:

1. Institutions do not internalise the externalities of network membership, so the level of optimised liquid assets and capital held by financial institutions may be suboptimal from the point of view of minimising systemic risk

2. In addition to ex-post stability effects of capital requirements, there may be positive ex-ante effects of regulation on incentives
    - E.g. capital requirements and mark-to-market rules may deter financial institutions from taking excessive risks ex-ante

Policy Implications contin.

Recommendations

Because financial institutions do not internalise the externalities of network membership, banks liquidity choices will be suboptimal

$\rightarrow$ Liquidity and capital requirements need to be imposed externally

$\rightarrow$ Should be set in relation to a banks contribution to systemic risk, rather than on the basis of the banks idiosyncratic risk

Landier, Greenwood, and Thesmar (2015), "Vulnerable Banks", JFE

Paper 2 - Greenwood et al. (2015)

Greenwood, Landier and Thesmar (2015),

"Vulnerable Banks", *Journal of Financial Economics*

Empirical application
of a fire-sale contagion model
on European banking sector data

Contribution

How did the paper help understand systemic risk?

- Presents a measure of systemic risk capturing feed-back effects
- Derives a model of *bank deleveraging through asset fire-sales* which can be used to evaluate post-shock policy interventions
- Applies the model to European Banking sector
- Evaluates which policy measures would have been useful to mitigate fire-sale losses during the Euro sovereign debt crisis 2010 - 2011

Greenwood et al. (2015)'s framework

Model on shock propagation in a banking sector[5]:

1. Initial shock: An initial exogenous shock hits the banking system. This can be a shock to one or several asset classes, or to equity capital.
2. Direct losses: Banks holding the shocked assets suffer direct losses which lead to an increase in their leverage.
3. Asset sales: In response to the losses, banks sell assets and pay off debt.
4. Price impact: The asset sales have a price impact that depends on each assets liquidity and the amount sold.
5. Spilloverlosses: Banks holding the fire-sold assets suffer spillover losses.

[5] following Duarte and Eisenbach (2013) description

Model

Model (1)

Periods : $T = 1, 2$

N banks, each bank n is financed with debt and equities, has leverage ratio b_{nt} asset portfolio weights m_{nk} and total assets a_{nt}

Assets	Liabilities	
$m_k \; a_t$	Equity e_t	$\left.\right\} a_t$
	Debt D_t	

- A_t is a diagonal NxN matrix so that each diagonal $a_{nt} = d_{nt} + e_{nt}$ at date t
- B_t is a diagonal NxN matrix so that each diagonal term $b_{nt} = d_{nt}/e_{nt}$ at date t
- M is a NxK matrix containing weights of each asset k for each bank n
- R_t is a matrix with banks' returns in each period t, with

$$R_t = MF_t \qquad (8)$$

- F_t is a $Kx1$ vector with asset net returns

Model (2)

Assumption 1 -
Banks keep leverage ratio B_t constant

R_1 in $t = 1$

Calculating net asset sales:

- $A_1 B_1 R_1$; a $Nx1$ vector

  $R_1 > 0$, banks have to borrow more to preserve leverage ratio
  $R_1 < 0$ banks have to sell assets to deleverage

- In a situation where exogenous shock is big enough to wipe out all existing assets: $A_1 max(BR_1; 1 - R_1)$

Model (3)

Assumption 2 -
Fixed target exposures M

Which assets are sold?
Banks sell proportionally to their existing holding strategy,
i.e. M remains constant between dates 1 and 2

- $\phi = M' A_1 B R_1$ (9); a $Kx1$ vector of net asset purchases
    - total asset purchases for bank n facing R_1 are $a_n b_n R_{1n}$
    - net purchases of asset k for a given bank are $m_{nk} a_n b_n R_{1n}$

Model (4)

Assumption 3 - Price impact

In the second period, asset sales ϕ generate price impact

- $F_2 = L\phi \qquad (10)$

    - L is a diagonal matrix of price impact ratios in units of returns per dollar of net purchase

      Price impact is linear and proportional to the dollars of the asset being sold by all other financial institutions
      L = 0 if perfect liquidity holds

- in $t = 2$:
  $R_2 = MF_2 = ML\phi = (MLM'BA_1)R_1 \qquad (11)$

Model (5)

Measures of systemic risk

1) Aggregate Vulnerability
   - Take (4) and pre-multiply by $1'A_1$ and divide by total banking sector equity 'pre-deleveraging' E_1 which yields:

$$AV = \frac{(1'A_1 MLM'BA_1)R_1}{E_1} \qquad (12)$$

   - Percentage of aggregate bank equity that would be wiped out by bank deleveraging in case of F_1.
     Rearranging yields:

$$\begin{aligned} AV \times E_1 &= \sum_n \gamma_n b_n a_{n1} r_{n1} \\ \textit{with} \quad \gamma_n &= \sum_k \left(\sum_m a_m m_{mk} \right) l_k m_{nk} \end{aligned} \qquad (13)$$

     where γ_n is the *connectedness* of each bank n. γ_n is high when the bank owns large illiquid amounts of assets which are also held by other banks.

Model (6)

2) Systemicness

- From (5) we can deduct the individual contribution of bank n to aggregate financial sector vulnerability

$$S(n) = \frac{1' A_1 MLM' BA_1 \delta_n \delta_n' MF_1}{E_1} \tag{14}$$

where δ_n is $Nx1$ vector with all zeros except the n^{th} element
Rearranging yields:

$$S(n) = \gamma_n \left(\frac{a_n}{E_1} \right) \times b_n \times r_{n1} \tag{15}$$

- $S(n)$ is the **systemicness** of bank n and is higher, the higher the leverage b_n, the higher connectedness (n owns illiquid and large assets hold by other banks), the bigger the bank ($\frac{a_n}{E_1}$ is large) and the larger the shock r_1

Model (7)

3) Indirect Vulnerability

- The *indirect* effect of other banks' asset sales on bank's n equity is

$$IV(n) = \frac{\delta_n' A_1 M L M' B A_1 M F_1}{e_{n1}} \tag{16}$$

$$IV(n) = \underbrace{(1 + b_n)}_{\text{leverage}} \times \underbrace{\sum_k \left[\underbrace{l_k m_k}_{\substack{\text{illiquidity-weighted} \\ \text{exposure of asset k}}} \times \underbrace{\left(\sum_{n^t} m_{n^t k} \alpha_{n^t} b_{n^t} r_{n^t} \right)}_{\text{fire sales of asset k}} \right]}_{\text{connectedness}}$$

$IV(n)$ gives the share of bank n equity that will be wiped out *indirectly* through other banks' deleveraging following exogenous shock F_1

Model (8)

Continuation of IV:

IV implies:

- leverage effect (first term): given asset shock has bigger impact on equity if the bank is more leveraged
- connectedness effect (second term): Large when bank owns assets that are illiquid and exposed to heavy fire sales

Direct Vulnerability

- The *direct* effect of F_1 on bank n's assets

$$DV(n) = \frac{\delta_n' A_1 M F_1}{e_{n1}} \tag{17}$$

$DV(n)$ gives the share of bank n equity that will be wiped out *directly* from the effect of the exogenous shock F_1 on its assets

Model (9)

Systemicness vs Indirect Vulnerability vs Direct Vulnerability

- For each bank n we can distinguish three measures of financial system fragility:

$$S(n) = \frac{1' A_1 MLM' BA_1 \delta_n \delta_n' MF_1}{E_1} \tag{18}$$

$$IV(n) = \frac{\delta_n' A_1 MLM' BA_1 MF_1}{e_{n1}} \tag{19}$$

$$DV(n) = \frac{\delta_n' A_1 MF_1}{e_{n1}} \tag{20}$$

- Distinction between **systemicness** and **vulnerability**: bank size enters equation (11), but not (12) or (13) Intuition: a small bank can be vulnerable but not systemic
- IV (12) is driven by leverage and shock exposure of its assets, while DV(13) is only driven by asset exposure

Empirical analysis

Empirical Application

European sovereign debt crisis 2010 - 2011

Approach: Look at correlation between 'computed' bank vulnerability and 'real' equity drawdowns experienced by banks

Data:

- Balance sheets for the 90 largest banks in the EU27 countries
- 42 asset classes, book leverage ratio (a cap at 30 is imposed on 20banks)
- Price impact matrix $L = 10^{-13} \times Id$, where Id is a 42×42 diagonal matrix of ones $\rightarrow$ EUR10bn of trading imblances lead to a price change of 10 basis points

Results

- Shock F_1:

  Assuming a -50% writedown in GIIPS (Greek, Italian, Irish, Portugal, Spain) debt.

  F_1 vector is 0 for all 42 assets, except for the 5 GIIPS asset classes where it's -50%

- Aggregate effect $1' A_1 M F_1$ of F_1 on banking sector is EUR381bn, or 40% of the banking sector

Results

Compute IV, DV and S for every bank n

	Indirect vulnerability as a fraction of equity		Direct vulnerability as a fraction of equity	
Bank name	$IV(n)$ (1)	Rank (2)	$DV(n)$ (3)	Rank (4)
Allied Irish Banks	35.24	1	11.9	2
Agricultural Bank of Greece	12.98	2	33.5	1
West LB	8.80	3	0.9	25
Banca Monte Dei Baschi di Siena	5.08	4	3.7	3
Oesterreichische Volksbank	4.83	5	0.2	56
SNS Bank	4.71	6	0.3	55
Caixa de Aforros	4.70	7	1.4	11
NordDeustche Landesbank	4.61	8	0.4	51
Commerzbank AG	4.54	9	1.0	21
Caixa d'Estalvis de Catalunya	4.36	10	0.8	31
Full sample average	3.02		1.11	

Results

Table 3

Systemicness ranking in response to a GIIPS (Greek, Italian, Irish, Portuguese and Spanish) shock.

We calculate the systemicness $S(n)$ of each individual bank, assuming a 50% write-off on GIIPS sovereign debt. Systemicness is defined in Eq. (7) and refers to the contribution of a particular bank to the aggregate vulnerability of the banking system. We report detailed information for the top 10 systemic banks. Columns 2, 3, and 4 report the elements of the decomposition of systemicness from Eq. (8). Column 2 reports total exposure of each bank, normalized by aggregate equity. Column 3 reports the fraction of assets that would be fire-sold as a fraction of total exposure. Because of our cap, it is always smaller than one. Column 4 focuses on the linkage effect. The last line presents the sum of systemicness over the 90 banks in our sample, which is equal to aggregate vulnerability *AV*. A 50% write-down on GIIPS debt would wipe out, through deleveraging, 245% of total bank equity. Our decomposition accounts for the fact that fire sales induced by the write-off are capped by total assets.

Bank name	Systemicness $S(n)$ (1)	Assets/aggregate banking system equity $\left(\frac{a_{n1}}{E_1}\right)$ (2)	Fire sales $\max(b_n\delta'_n MF_1, 1-\delta'_n MF_1)$ (3)	Linkage effect γ_n (4)
Banco Santander	0.21	1.06	0.58	0.34
Unicredit	0.19	0.88	0.69	0.31
Intesa SanPaolo	0.19	0.62	0.95	0.33
BBVA	0.18	0.57	0.94	0.33
BNP Paribas	0.15	1.37	0.36	0.30
BFA-Bankia	0.12	0.29	0.95	0.42
Caja de Ahorros Y Pensiones de Barcelona	0.10	0.27	0.93	0.38
Societe Generale	0.07	0.75	0.32	0.32
Commerzbank AG	0.07	0.66	0.48	0.23
Banca Monte Dei Baschi di Siena	0.06	0.22	0.92	0.32
Full sample average	0.03	0.27	0.44	0.30
Full sample total *AV*	2.45			

Results

- IV and DV are not correlated
- Average bank would lose 111% of its equity from the direct effect and further 302% of its equity through IV (i.e. deleveraging of other banks)
- Systemicness is correlated with bank size (Spearman's 0.52, 1%)
- The sum of systemicness across all 90 banks(AV) is 2.45, meaning that 245% of aggregate bank equity would be wiped out. This is 6times larger than the direct aggregate effect of wipe off 40% of balance sheets

Policy Evaluation

- GIIPS debt *re-nationalisation* reduces systemic risk significantly
- *Euro bonds* lead to a 'reshuffling' of assets across banks and increase *AV*
- *Leverage cap* has to be of large magnitude to decrease systemic risk and comes at great cost
  - E.g.: Capping leverage at 25, and not 30, reduced vulnerability from 245% to 238% and banks would have to raise EUR480bn

- Merging of exposed banks with unexposed banks increases systemic risk by 20% as assets that were unexposed previosuly become contaminated by poor GIIPS performance
- Optimizing Capital Injection is the most cost-efficient and effective policy measure to reduce AV. Policy makers have cash to invest in bank equity to reduce the spillovers between banks in a deleveraging cycle. They have to first identify banks that are less connected (i.e. their portfolios differ from other banks) or smaller (recapitalisation cost is smaller). For example an optimal injection of EUR200bn reduced AV by 26%

Policy Evaluation contin.

- GIIPS debt re-nationalisation reduces systemic risk significantly
- Euro bonds lead to a 'reshuffling' of assets across banks and increase *AV*
- Leverage cap has to be of large magnitude to decrease systemic risk and comes at great cost(in the example capping leverage at 25, and not 30, reduced vulnerability from 245% to 238% and banks would have to raise EUR480bn)
- Merging of exposed banks with unexposed banks increases systemic risk by 20% as assets that were unexposed previosuly become contaminated by poor GIIPS performance

- Optimizing Capital Injection is the most cost-efficient and effective policy measure to reduce *AV*.
    - Policy makers have cash to invest in bank equity to reduce the spillovers between banks in a deleveraging cycle.
    - They have to first identify banks that are less connected (i.e. their portfolios differ from other banks) or smaller (recapitalisation cost is smaller). E.g. an optimal injection of EUR200bn reduced *AV* by 26%

Conclusion

Main results

- Derivation of the *systemicness* measure S, i.e. a bank's contribution to financial sector fragility
  - A bank's S is proportional to the product of bank size, connectedness and leverage
  - What is high connectedness? When bank owns large and illiquid asset classes to which other banks also have high exposure

Conclusion contin.

- Evaluation of policy interventions
    - Forced mergers of most exposed bans would not have reduced systemic risk
    - Modest equity injections, if distributed appropriately between the most systemic banks, reduce vulnerability of banking sector to deleveraging by more than half

Contagion more likely when..
..asset classes are large in dollar terms and held by the most levered banks

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Thank you!