Vulnerable Banks

ROBIN GREENWOOD (HBS & NBER)
AUGUSTIN LANDIER (TOULOUSE)
DAVID THESMAR (HEC PARIS & CEPR)

NOVEMBER 2011

Systemic Risk

- Risk of collapse of financial system due to **contagion**

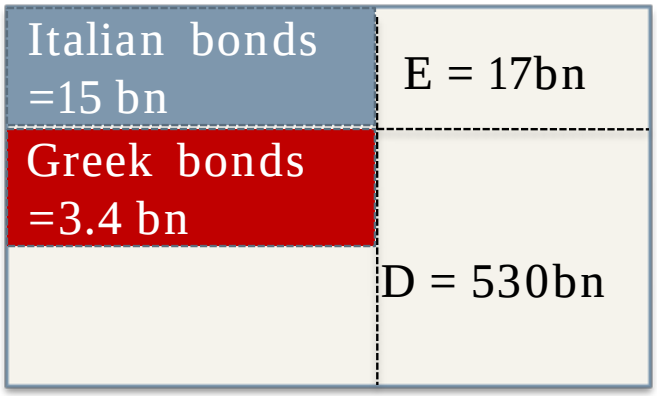
- Two kinds of **linkages**:
  - **inter-bank** contracts
  - **fire sales** spillovers: this paper

- Quasi-structural model of **liquidation spiral** → Measure of:
  - *Vulnerability of each bank to systemic risk*
  - *Contribution of each bank to systemic risk*
  - *Interconnectedness between 2 banks*
  - *Aggregate vulnerability*

- **Applications:**
  - European banks & sovereign risk
  - US banks and financial institutions through the Lehman crisis

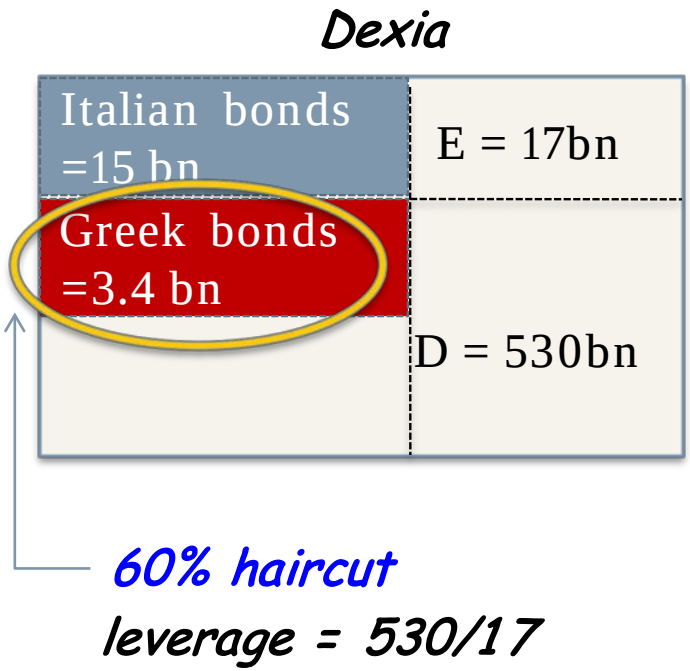
Intuition

Dexia

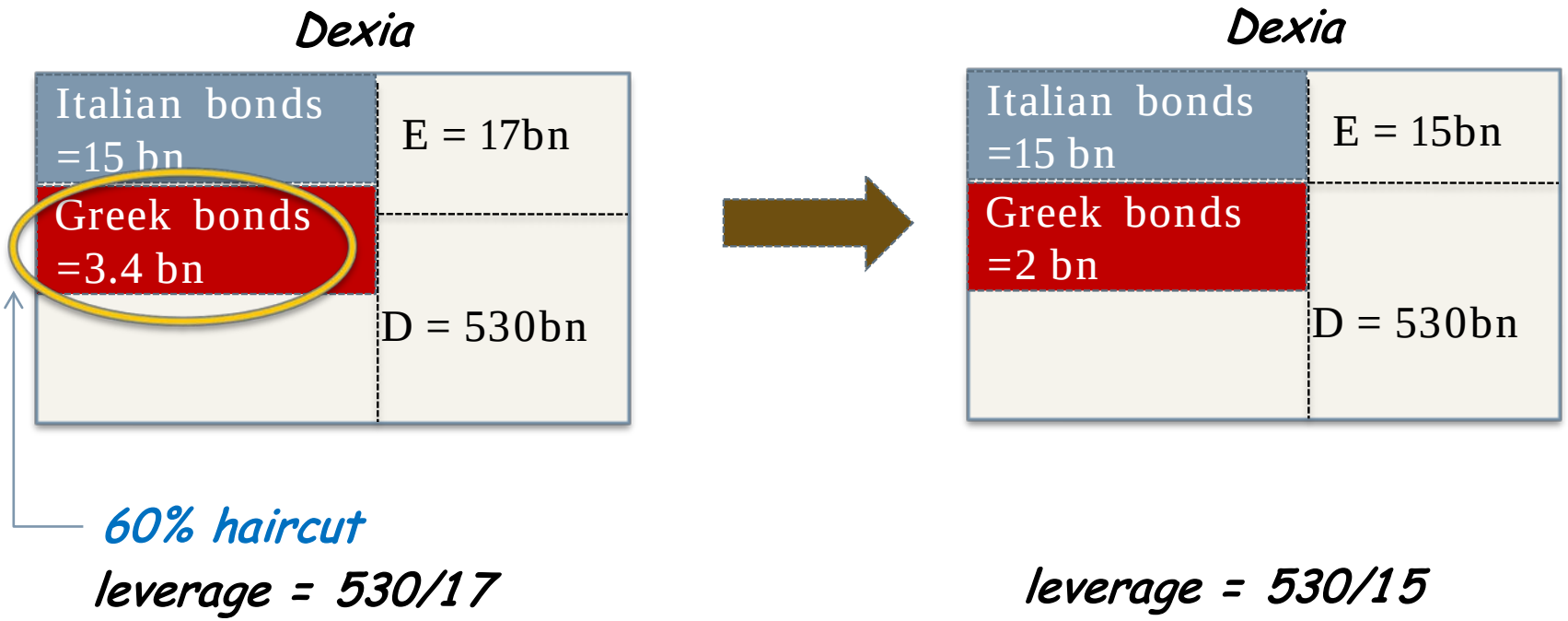


leverage = 530/17

Intuition

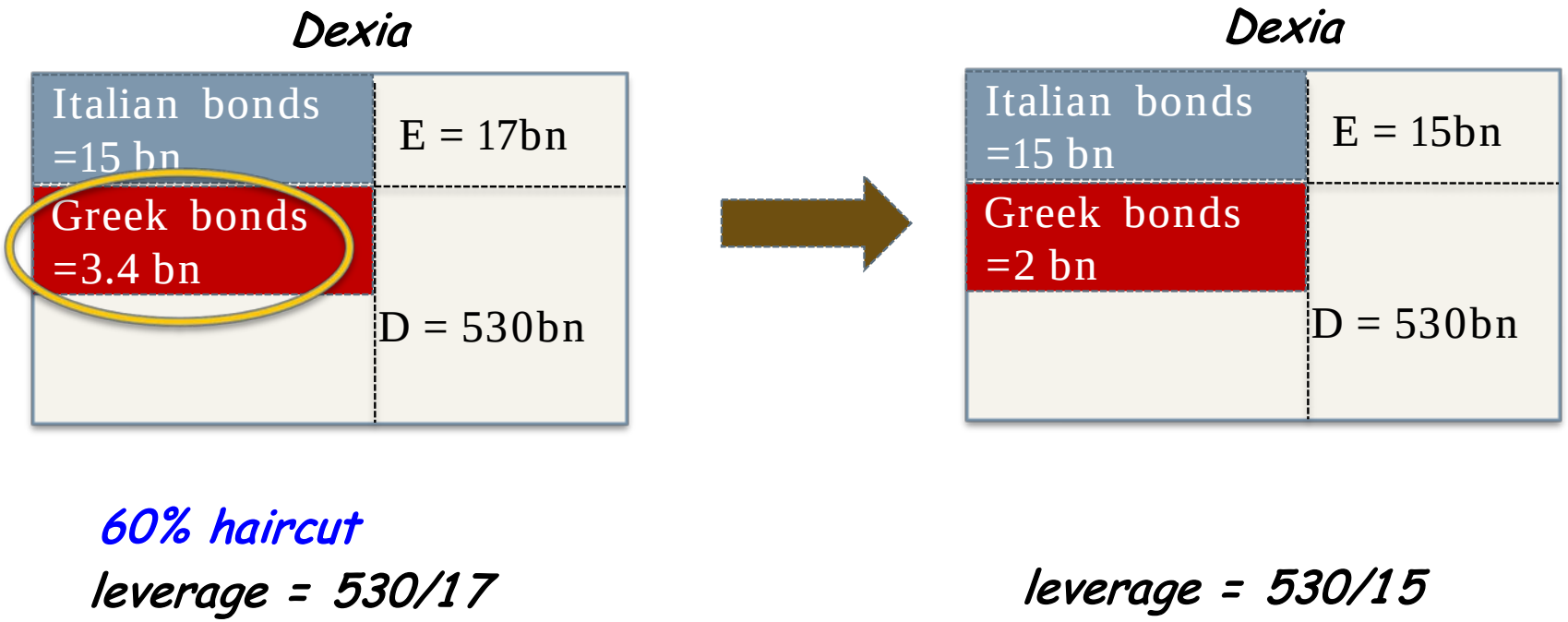

Dexia
Italian bonds =15 bn
E = 17bn
Greek bonds =3.4 bn
D = 530bn
60% haircut
leverage = 530/17

Intuition


Dexia
Italian bonds =15 bn
Greek bonds =3.4 bn
E = 17bn
D = 530bn
60% haircut
leverage = 530/17
Dexia
Italian bonds =15 bn
Greek bonds =2 bn
E = 15bn
D = 530bn
leverage = 530/15

Intuition

To keep same leverage (530/17),
DEXIA needs to sell (530/17)x 2 = 62bn of assets



60% haircut

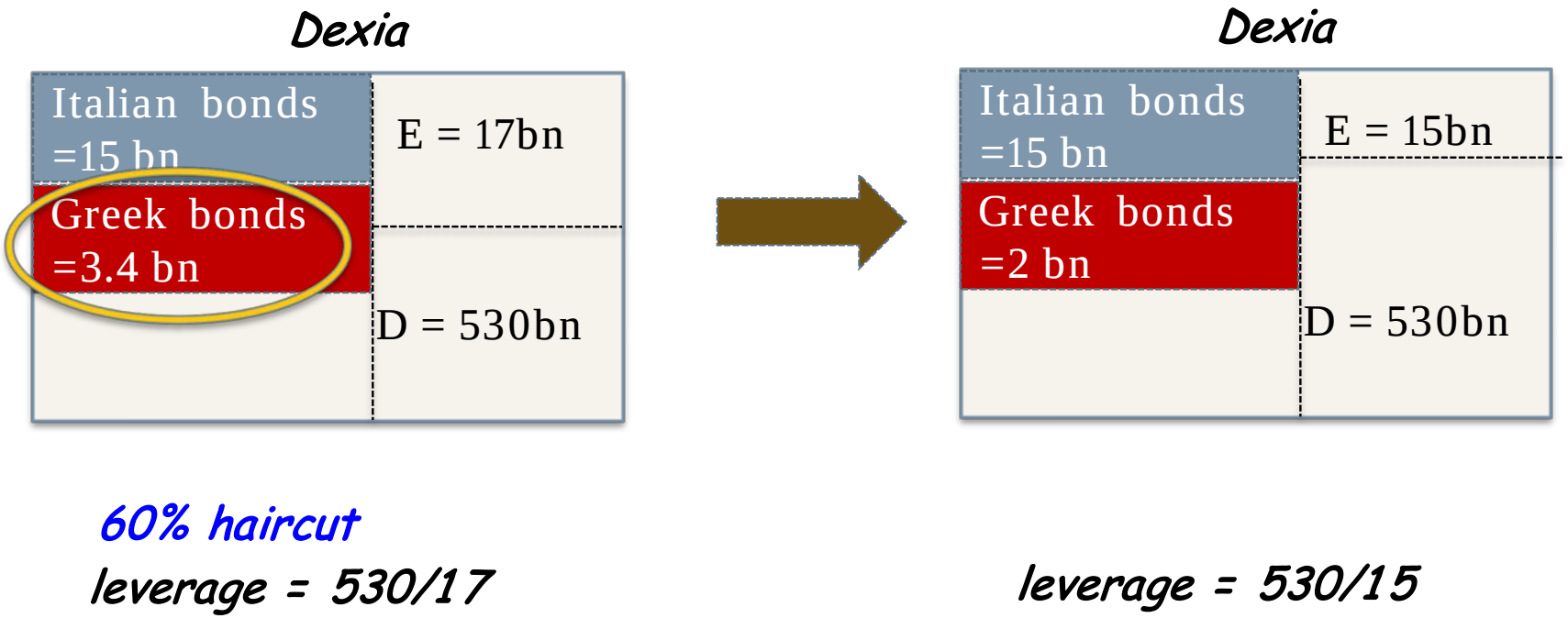
leverage = 530/17

leverage = 530/15

Intuition

To keep same leverage (530/17),
DEXIA needs to sell (530/17)x 2 = 62bn of assets

➔ *proportionally: 62 x 15 / 545 = 2bn of italian bonds*
➔ *price impact on Italian Bonds = 10e-11 x 2bn = 2%*

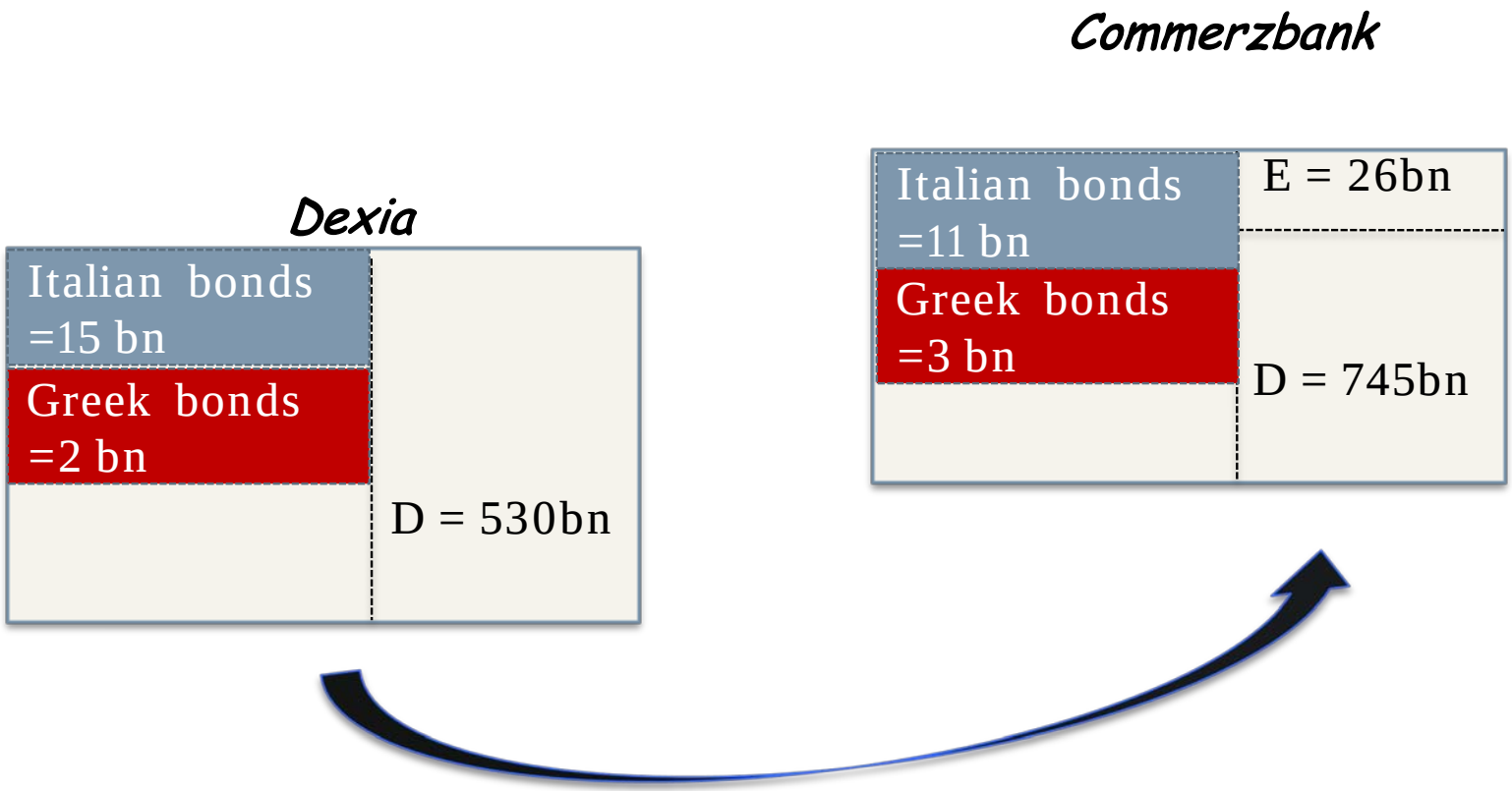


60% haircut

leverage = 530/17

leverage = 530/15

Intuition



Indirect contamination of *Commerzbank*:

Loss on Italy = 2% x 11bn = 220m

= 0.03% of assets

What this framework delivers

Empirical measures of how much:

- 1 bank can hurt the others ("***Systemicness***")
- 1 bank can be hurt by others ("***Vulnerability***")
- 2 banks are connected ("***Cross vulnerability***")
- Overall system is vulnerable ("***Aggregate vulnerability***")

Policy analysis :

- What if we merge one bank with another, what happens to systemic risk?
- What happens if we cap size or leverage?

3 Ingredients needed / Assumptions

- **What amount of assets do banks liquidate following shock?**
  - Assume they liquidate some assets to keep leverage constant
  - No equity issuance
- **In what proportions do they liquidate assets?**
  - Assume they liquidate in proportion to weight in existing holdings
    - Keep assets' weighting unchanged
- **Price impact of fire sales?**
  - Assume Amihud ratios: returns proportional to dollar sale

Framework: 3 steps

- **From asset shock to bank portfolio values**
  - Matrix of Bank holdings/ risk exposures
- **From leverage shock to fire sales / buys**
  - Liquidation rule (proportional)
- **From fire sales to bank returns**
  - Price impact

Notation

- *N* banks, *K* assets
- F_t = Vector of Asset Returns: $F_t = \begin{pmatrix} F_{1t} \\ \\ F_{Kt} \end{pmatrix}$
- *M* = Matrix of bank weights in diff't assets: $M = \begin{pmatrix} m_{11} & \dots & m_{1K} \\ & \dots & \\ m_{N1} & \dots & m_{NK} \end{pmatrix}$
- *B* = Diagonal matrix of bank leverage (d/e)
- A = Diagonal matrix of bank's asset values (in $ or Euro)
- *L* = Diagonal matrix of price impact ratios by assets

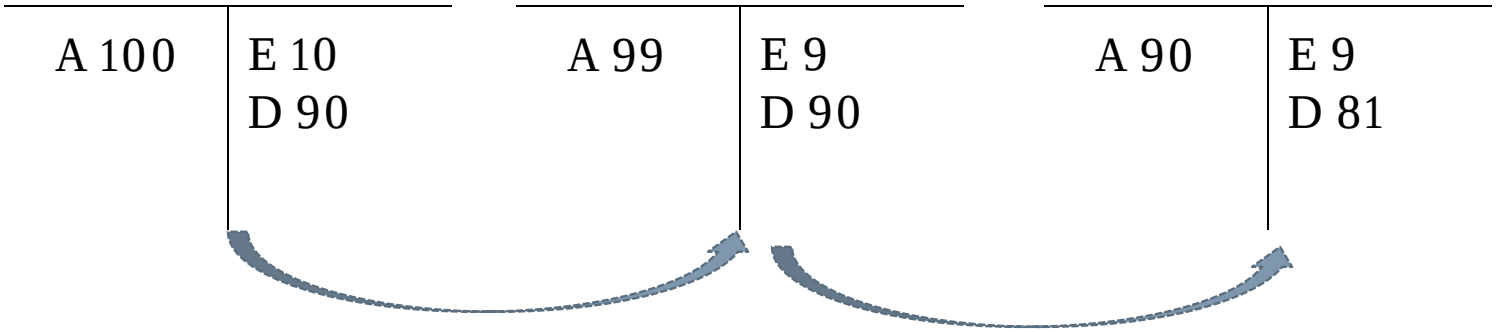
Step #1: from Asset shocks to Bank assets

- R = Vector of banks' **portfolio** returns (aka unlevered returns):

$$R_t = \begin{pmatrix} R_{1t} \\ \\ R_{Nt} \end{pmatrix} = M \; F_t + \varepsilon_t$$

Step #2: from bank shocks to fire sales

- Bank with assets=100; shock = -1.



- To keep leverage constant , need to sell - (d/e) x A x (-1%)

  ➔ In matrix terms: vector of dollar asset purchases/*sales* = **BAR_t**

- If asset A_1 is w% of portfolio: sale of A_1 = w x (d/e) x A_1 x (-1)

  ➔ In matrix terms: Vector of asset purchases/sales = **$M'BAR_t$**

Step #3: from assets sales to bank returns

- Order imbalances lead to temporary movements in asset prices

$$F_{t+1} = L \times \text{Net Asset Buys}$$

Illiquidity: Amihud ratios

- Bank returns are impacted by asset price movements

$$R_{t+1} = M \times F_{t+1} = ML \times \text{Net Asset Buys}$$

Combining the two last steps

- From bank shock to each Bank

$$R_{t+1} = ML \times \textbf{asset buys} = (MLM'BA) \times R_t$$

Connectedness Matrix

- From asset shock to each Bank

$$R_{t+1} = (MLM'BA) \times MS_t$$

Shock to Assets

Aggregate Vulnerability

- *S* is a vector of shocks to asset returns
  - Canonic case: 1 s.d. shocks to all assets
  - In Europe: shock to weak sovereigns

- Aggregate $ **indirect** impact of S on ***all*** bank assets (normalized by aggregate equity):

Aggregate Vulnerability:

$$AV = (1'AMLM'BAMS)/E$$

- Aggregate vulnerability high when large asset classes are held by banks that are relatively large, levered, exposed to volatile assets.
- Warning: Aggregate $ ***direct*** impact of S on banks : 1'AMS

Systemicness

- Systemicness of bank i, *S(i)* = aggregate indirect impact of shock S through bank i

$$S(i) = \frac{1'A_{t-1}MLM'BA_{t-1}e_ie_i'MS}{E_{t-1}}$$

$$= b_i \times \left(\frac{a_{i,t-1}}{E}\right) \times (e_iMS) \times (1'A_{t-1}MLM'e_i)$$

$$= \underbrace{b_i}_{\text{Higher leverage}} \cdot \underbrace{\frac{a_{i,t-1}}{E_{t-1}}}_{\text{Size}} \cdot \underbrace{\left(\sum_{k=1}^{K} m_{i,k}s_k\right)}_{\text{Exposure to shocked assets}} \cdot \underbrace{\sum_{k=1}^{K} l_k m_{i,k} \left(\sum_{j=1}^{N} a_{j,t-1}m_{j,k}\right)}_{\text{Holds illiquid assets held by rest of system}}$$

(Linkage effect)

- (AV = sum of all S(i))

Vulnerability

- Vulnerability of bank i to deleveraging

$$V(i) = \frac{e_i' A_{t-1} MLM' B A_{t-1} MS}{E_{it-1}}$$

$$= (1 + b_{it}) \cdot (e_i' MLM' B A_{t-1} MS)$$

- Careful: different from “direct” exposure:

$$V_0(i) = \frac{e_i' AMS}{E_{it-1}}$$

Cross-bank vulnerability

- Suppose bank *j* hit by shock…

- What is the impact on bank *i* ?

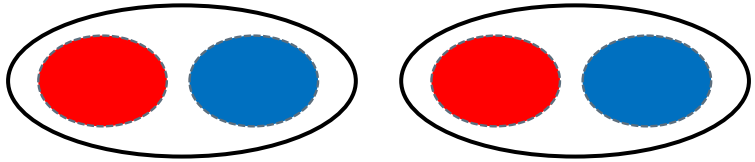
$$V(i,j) = \frac{e_i' A_{t-1} MLM' BA_{t-1} e_j}{E_{it-1}}$$

$$= b_j \cdot a_{jt-1} \cdot (1 + b_i) \cdot (e_i' MLM' e_j) \cdot$$

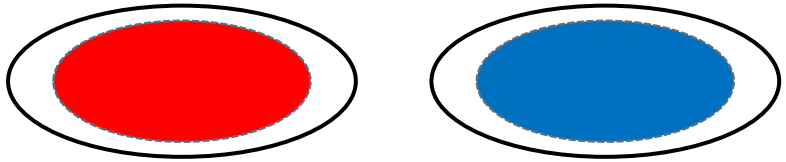
➔ This will serve to test the empirical validity of the framework

Building intuition: diversification

- Suppose 2 banks have identical leverage and there are two assets
- Which is best for aggregate systemic risk?
  - Both banks have identical portfolios?



  - Or each bank owns only one asset, and all of it ?

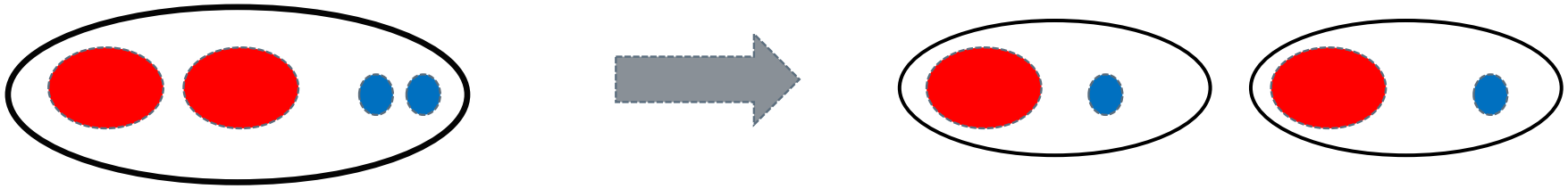


➔ Making banks similar is good iff most **volatile** asset is also most **illiquid**

- **Two opposing effects:**
  - Spreading volatile asset across banks → less average dollar liquidations
  - …But now some of the other asset will get liquidated

Systemic Intuition: slicing is neutral

- **Cut a bank into 2 banks of *similar asset weights and leverage*:**



- **Effect on Aggregate Vulnerability: NONE**

Systemic Intuition: mergers

- **Merge 2 banks:**

  - *Heterogeneous assets and leverage*

- **2 effects :**

  - **Leverage** of merged entity is smaller than asset-weighted leverage:
    →stabilizing

  - **Portfolio effect:** stabilizing *iff* most volatile also most illiquid

Applications-- Overview

- **Largest Euro banks**
  - Exposures taken from the EBA stress tests
- **Largest 100 US financial institutions**
  - Our estimates based on weekly market leverage and factor exposures
  - I will skip this today

European Banks

- **M** matrix (exposures)
  - EBA stress tests data (90 largest banks in the EU27; july 2011)
    - Sovereigns, per country
    - Mortgages, commercial real estate, corporate loans, retail SMEs, consumer loans
- **B, A, R** from datastream
  - Use book leverage (→can include private)
- Shock vector **S**
  - 50% write-down on all 5 PIIGS
- **L** = (10e-13) Id : identical liquidity of assets

Validation: Explaining Stock Returns

- Table 7: Compare realized stock returns (jan 2010-sep 2011)
- to V(i) Works even controlling for *direct* exposure to shock

	(1)	(2)	(3)	(4)	(5)	(6)
	Dependent Variable = Cumulative Stock Return: 2009/12 - 2011/9					
Indirect vulnerability	0.015***	0.007**	0.008**	0.012**	0.009**	0.007*
	[4.34]	[2.58]	[2.48]	[2.68]	[2.58]	[1.89]
Direct exposure to GIIPS		0.016***	0.014***		0.010***	0.006
		[2.91]	[2.73]		[2.70]	[1.36]
Assets / total bank assets			2.682			4.763
			[1.45]			[1.25]
Debt to Equity			0.003			-0.006
			[0.38]			[-0.50]
Constant	-0.435***	-0.441***	-0.545***	-0.472***	-0.468***	-0.441
	[-9.25]	[-9.61]	[-3.64]	[-6.43]	[-6.53]	[-1.51]
N	49	49	49	49	49	49
R-squared	0.089	0.136	0.164			

AV: Vulnerability ranking

- Table 6, PIIGS writedown

Bank_Name	Indirect Exposure (%)	Rank	Direct Exposure (%)	Rank	Size	Rank	Target leverage	Rank
Allied Irish Banks Plc	-41.30	1	-11.86	2	0.01	27	30	1
Agricultural Bank Of Greece S.A.	-15.50	2	-33.55	1	0.00	48	30	1
Banca Monte Dei Paschi Di Siena S.P.A	-5.94	3	-3.75	3	0.01	23	30	1
Sns Bank Nv	-5.59	4	-0.31	33	0.00	38	30	1
Commerzbank Ag	-5.27	5	-0.96	16	0.03	12	30	1
Caja De Ahorros Del Mediterráneo	-4.72	6	-1.53	6	0.00	37	30	1
Banco Popolare - S.C.	-4.51	7	-1.50	7	0.01	30	30	1
Danske Bank	-4.50	8	-0.06	43	0.02	17	30	1
Bankinter	-4.38	9	-0.94	17	0.00	40	25	14
Ing Bank Nv	-4.34	10	-0.20	36	0.04	8	30	1
Deutsche Bank Ag	-4.20	11	-0.21	35	0.05	5	30	1
Banco De Sabadell	-4.12	12	-1.06	14	0.00	34	25	13
Banco Comercial Português	-3.71	13	-1.06	15	0.00	33	27	10
Svenska Handelsbanken Ab (Publ)	-3.71	14	-0.00	46	0.01	19	26	12
Bank Of Ireland	-3.68	15	-0.54	28	0.01	26	29	8
Abn Amro Bank Nv	-3.54	16	-0.07	41	0.01	18	24	16

$S(i)$: Systemicness

- Table 8, PIIGS writedown

Rank	Name	Systemicness $S(i)$	Debt to Equity (b_i)	Assets / Aggregate Equity (a_i/E)	Exposure to shock $(e_i MS)$	Linkage effect $(1\ AML\ M\ e_i)$
1	Intesa Sanpaolo S.P.A	0.23	21.43	0.62	0.05	0.33
2	Banco Bilbao Vizcaya Argentaria	0.22	20.87	0.57	0.06	0.33
3	Banco Santander S.A.	0.21	23.00	1.06	0.03	0.34
4	Unicredit S.P.A	0.19	22.39	0.88	0.03	0.31
5	Banca Monte Dei Paschi Di Siena	0.17	30.00	0.22	0.08	0.32
6	Caja De Ahorros Y Pensiones De Barcelona	0.16	22.38	0.27	0.07	0.38
7	Bfa-Bankia	0.16	28.63	0.29	0.05	0.42
8	Bnp Paribas	0.15	22.62	1.37	0.02	0.30
9	Societe Generale	0.07	24.56	0.75	0.01	0.32
10	Commerzbank Ag	0.07	30.00	0.66	0.02	0.23
11	Banco Popolare - S.C.	0.07	30.00	0.13	0.05	0.36
12	Barclays Plc	0.06	17.52	0.90	0.01	0.34
13	Ing Bank Nv	0.06	30.00	0.95	0.01	0.36
14	Deutsche Bank Ag	0.06	30.00	1.15	0.01	0.30
15	Credit Agricole	0.06	27.01	1.36	0.01	0.25
16	Dexia	0.05	29.37	0.54	0.02	0.14
17	Banco De Sabadell	0.04	25.26	0.10	0.04	0.40

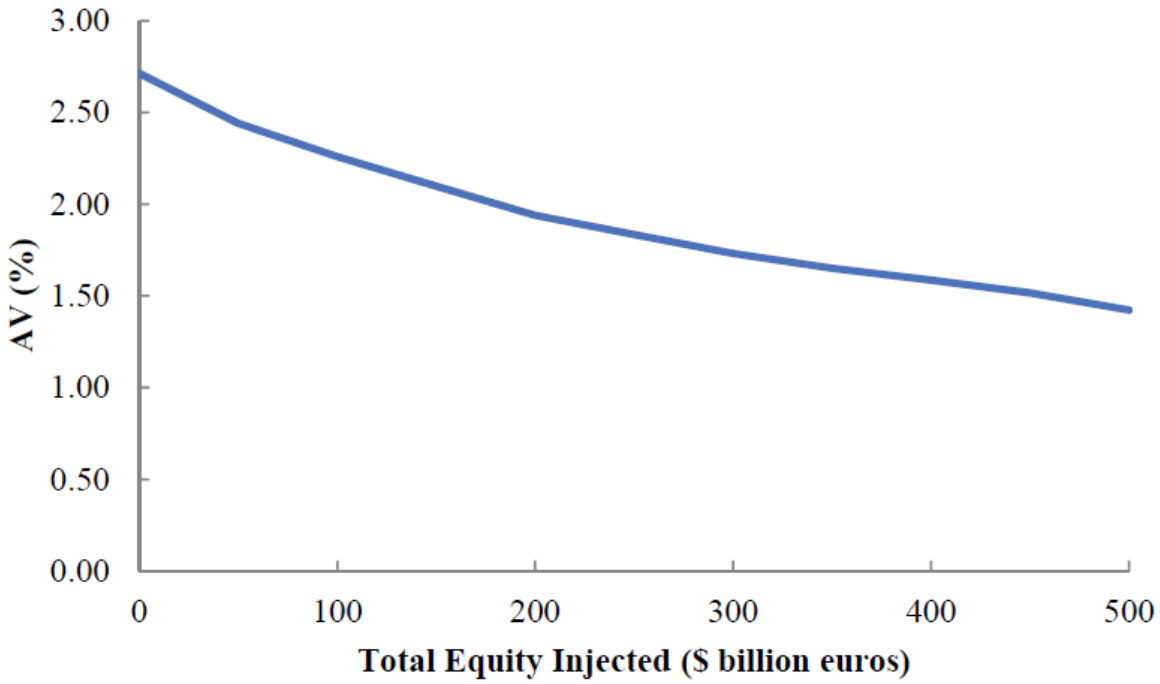
Policy Interventions

- **Table 9**
- Consider
  - Baseline
  - Size cap (500, 900, 1300 bn euros)
  - Cap leverage
  - Merge banks which are most directly exposed to writedown shock

- Of these interventions, only leverage caps have a major effect
  - But requires massive rebalancing: 480bn euros to cap leverage @ 15
- Size cap does not work b/c larger banks are not more levered
- Merging banks does not work b/c of two countervailing forces

Optimal Equity Injections

Panel B: Aggregate vulnerability to a 50% write-off to GIIPS debt (per euro of ag



By design, optimal injection in a given bank has strong correlation with overall systemicness

Summary

- Simple framework yields number of useful measures and insights
- Our key contribution relative to other measures
  - Quasi-structural but highly tractable
  - Isolating specific mechanism (fire sale contagion)
  - Able to perform policy experiments
- Regulating through liquidation constraints?
- Still more to do to on robustness
- More detail in the paper on all of this