Vulnerable Banks

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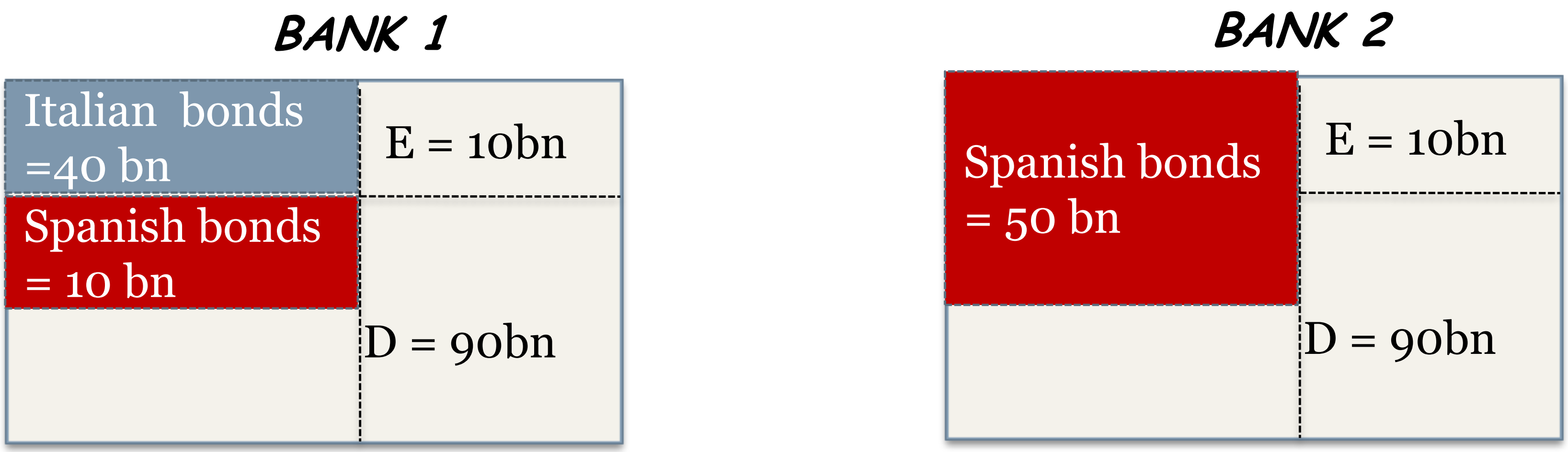
Systemic Risk

- Goal: measuring systemic risk with model that can be brought to the data.
  - Two kinds of **linkages**:
    - **Inter-bank** contracts → *rare data (yet), lots of papers*
    - **Deleveraging externalities**: → *this paper*

- What we do:
  - **Quasi-structural, extremely stylized, model of liquidation spirals**
  - **Estimation on actual data:**
    - European banks & sovereign risk
    - To measure systemic risk & make policy experiments

- Why focus on deleveraging externalities?
  - Less empirical studies
  - We have data
  - Rise of shadow banks

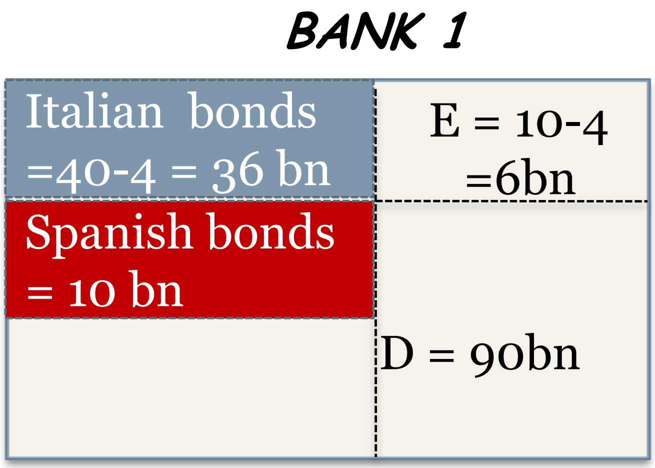
Intuition: 2 Banks & 2 Assets



leverage = D/E = 9

Intuition: 2 Banks & 2 Assets

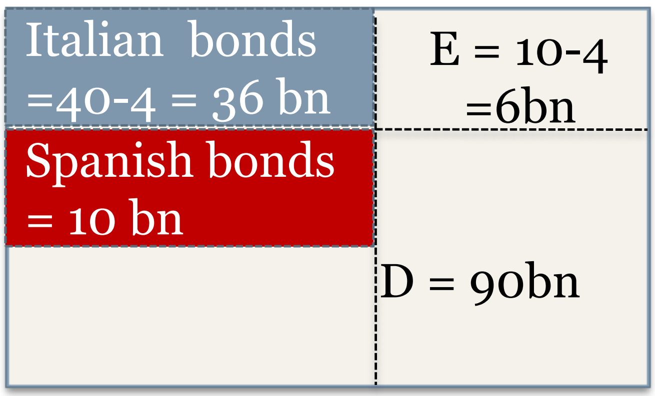
10% haircut on Italy



Intuition: 2 Banks & 2 Assets

10% haircut on Italy → Leverage of Bank 1= 90/6 >9

BANK 1



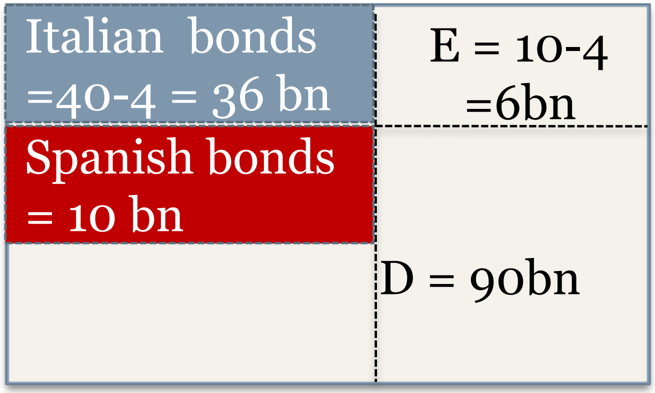
Intuition: 2 Banks & 2 Assets

10% haircut on Italy

→ Leverage of Bank 1= 90/6 >9

→To keep **same** leverage (9),
need to **sell** 9 x 4 = **36 bn of assets**

BANK 1



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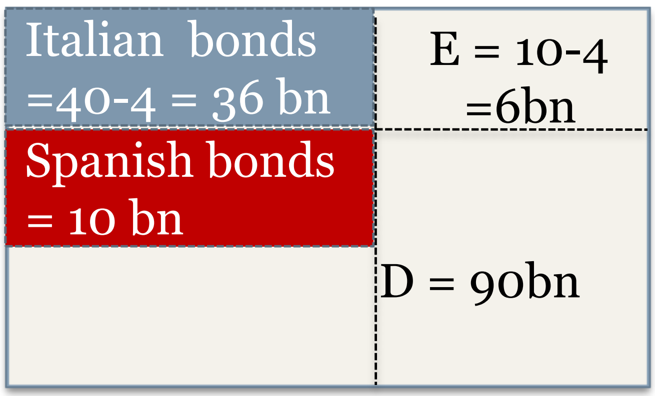

- **What assets? E.g. Proportionally** :

  → Sell 36/96=37.5% of each asset
  → Sell 3.75 Bn of Spanish Bonds

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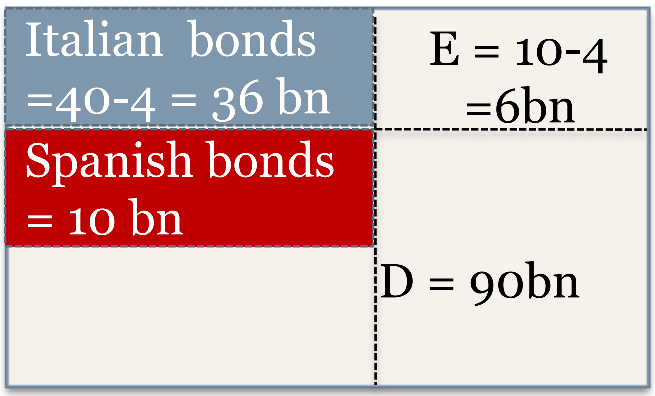

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→ ***Price impact on Spanish Bonds :***

λ x 3.75bn = 10e-13 x 3.75bn = 37.5bp

Intuition: 2 Banks & 2 Assets

10% loss on Italy

BANK 1

Assets	Liabilities
Italian bonds =40 bn	E = 10bn
Spanish bonds = 10 bn	D = 90bn

3.75% loss on Spanish bonds
(liquidation impact)

Indirect contamination of Bank 2

BANK 2

Assets	Liabilities
Spanish bonds = 50 bn	E = 10bn
	D = 90bn

Loss on Spain = 3.75% x 50bn = 1.9 Bn
= 19% of equity

Generalization:
N banks, K assets / The « M » Matrix

	Asset1	Asset2		Asset j		AssetK
Bank 1						
Bank2						
Bank i				M(i,j)		
Bank N						

Question:
How will a shock to Asset *j* affect Bank *i*
through deleveraging behavior of other banks?

Assumptions Needed

- **What *amount* of assets do banks liquidate following shock?**
  - We assume they liquidate some assets to keep leverage constant
    - No equity issuance
- **In what *proportions* do they liquidate assets?**
  - We assume they liquidate in proportion of existing holdings
    - Keep assets' weighting unchanged
- **Price impact of fire sales?**
  - Assume exogenous Price-Impact ratios:
    - returns proportional to dollar sale (e.g. Amihud ratios)
- *(Model is flexible enough to accommodate more complex rules)*

What this framework delivers

Empirical measures of how much:

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

Can perform policy counterfactuals:

- Systemic risk impact of Bank mergers?
- What happens if we cap size or leverage?

Literature and background: measuring structural risk

- Measuring bank default probability with CDS spreads
  - CDS spread contains counterparty risk → bank default probability
  - Ang and Longstaff (10), Giglio (11)
- Correlation of stock returns
  - When it is high, portfolios are very similar
    - Billio, Getmansky, Lo, Pelizzon (10)
  - Bank return conditional on market crash
    - Acharya&al (11) = vulnerability in our model
  - Market return conditional on bank crash
    - Adrian&Brunnermeier (11) = systemicness in our model
- Fast growing literature on direct interconnectedness
- Our stuff= Structural model
    - Focuses on deleveraging externalities
    - Uses (simplified) economic behavior
    - Uses data on these behaviors instead of market price movements

outline

- The model
- European application
- Conclusion

Three steps

Step #1: From asset shocks to banks dollar losses

Step #2: From bank dollar losses to asset sales

Step #3: From asset sales to banks' assets

Three steps

Step #1: From asset shocks to banks dollar losses

Three steps

Step #1: From asset shocks to banks dollar losses

$\$ \text{ bank Losses}_t = - A \times M \times F_t$

Vector of asset returns (shock)

Matrix of banks' portfolio weights

Diagonal matrix of banks' $ assets

Three steps

Step #1: From asset shocks to banks dollar losses

$$\$\ \text{bank Losses}_t = -\,A \times M \times F_t$$

Step #2: From bank dollar losses to $ asset sales

Three steps

Step #1: From asset shocks to banks dollar losses

$\$$ bank Losses$_t$ = - A x M x F$_t$

Step #2: From bank dollar losses to $ asset sales

$\$$ Asset sales = M' x B x $\$$ bank losses$_t$

Diagonal matrix of bank leverages (assumption: leverage kept constant)

Transposed matrix of banks' portfolio weights (assumption: portfolios kept unchanged)

Three steps

Step #1: From asset shocks to banks dollar losses

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Step #3: From asset sales to banks' returns

Bank returns$_{t+1}$ = - M x L x $\$$ Asset sales

Portfolio weights

Diagonal matrix of liquidity factors (amihud)

Combining the 3 steps

- From bank shock to each Bank

$$R_{t+1} = -M \times L \times (M'B) \times (A \times M \times F_f) = (MLM'BAM) \times F_t$$

price impact On assets

Deleveraging rule

Initial $ Shock to bank Assets

→ We focus only on 1-period dynamics:

Shock → deleveraging → bank returns

What we can measure

- R = (MLM'BAM) x F
- **"indirect Vulnerability" of bank n** = n^{th} element of (AMLM'BAM) x F
  - Normalize by bank n equity
  - Careful: different from "direct vulnerability" AMF

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- "systemicness" **of bank n** = 1'x(MLM'BAδ_nM) x F
  - Normalize by aggregate bank equity
  - where 1 = vector of ones & δ_n =matrix of zeros with only (n,n) element=1
  - Different from indirect vulnerability
  - Big if n is levered, owns same assets as others, is big, is exposed

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- **"aggregate systemicness"** = 1'x(AMLM'BAM) x F
  - Sum of individual banks' "systemicnesses"

Systemicness: decomposition

Connectedness x Size X Leverage X Direct Exposure

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

Size

Leverage

Direct Exposure

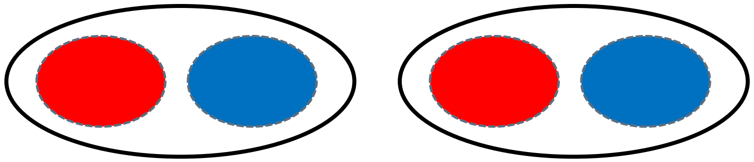
Connectedness

$$\gamma_n = \sum_k \left(\sum_m a_m m_{mk} \right) l_k m_{nk}$$

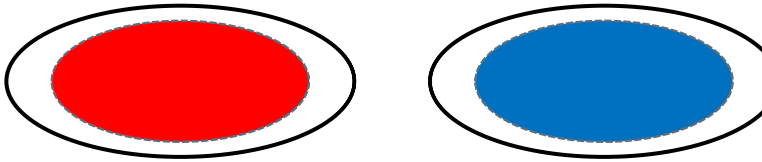
Bank holds illiquid assets that are held in large quantities by others

Some Intuition: Diversification can be bad

- Assume: 2 banks, identical leverage and 2 assets
- Which is best for “aggregate systemicness”?
  - Both banks have identical portfolios?



  - Or each bank owns 100% of one asset ?

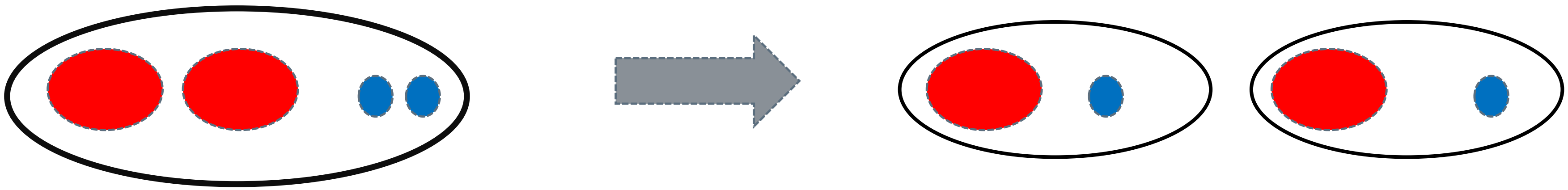


- **Two opposing effects:** Spreading volatile asset across banks
  → less average dollar liquidations of that asset
  …But now some of the other asset will get liquidated

→Diversification good when **stable** assets is the <u>most liquid</u>

Some Intuition: Too big to Fail ?

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



- **Effect of "slicing" bank on "Aggregate Systemicness": NONE**
  - Two opposite forces: too big to fail vs too many to fail
  - formally: the model is scale-free, a by-product of the price impact equation ($ → returns)

Some Intuition: Mergers

- **Merge 2 banks:**

  - *Heterogeneous assets and leverage*

- **2 effects :**
  - **Portfolio effect →** stabilizing if most **stable** asset is liquid
  - **Leverage effect →** stabilizing if most levered bank holds more illiquid asset

European Banks

- **M** matrix (portfolio weights)
  - 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
    - **Sovereigns=13% total assets**

- **B (leverages), A ($ sizes)** from Datastream
  - Use book leverage (→Can include private banks)

- Shock vector **F**
  - 50% write-down on the 5 GIIPS

- **L** = (10e-13) Id : Identical liquidity of all assets
  - 10 bn dollar trading → 10 bp return impact

Vulnerability rankings indirect vs. direct

Bank_Name	Indirect Vulnerability as a Fraction of Equity *IV(n)*		Direct Vulnerability as a Fraction of Equity *DV(n)*	
ALLIED IRISH BANKS PLC	35.24	1	11.9	2
AGRICULTURAL BANK OF GREECE	12.98	2	33.5	1
WESTLB AG, DÜSSELDORF	8.80	3	0.9	25
BANCA MONTE DEI PASCHI DI SIENA	5.08	4	3.7	3
OESTERREICHISCHE VOLKSBANK AG	4.83	5	0.2	56
SNS BANK NV	4.71	6	0.3	55
CAIXA DE AFORROS DE GALICIA, VIGO	4.70	7	1.4	11
NORDDEUTSCHE 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	

Validation: Explaining Stock Returns

- Table 2: explain realized stock returns (Jan 2010-Sep 2011)
- Compare IV and DV: works even controlling for *direct* exposure

	(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			

$S(n)$: Systemicness

- Table 3, GIIPS writedown

Bank Name	Systemicness $S(n)$	Assets / Aggregate Equity (a_{nn}/E)	fire sales $min(-b_{nn}\ \delta'_n MF_1, 1+\delta'_n MF_1)$	Linkage effect $(1'AMLM'\delta_n)$
BANCO SANTANDER S.A.	0,21	1,06	0,58	0,34
UNICREDIT S.p.A	0,19	0,88	0,69	0,31
INTESA SANPAOLO S.p.A	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 PASCHI DI SIENA S.p.A	0,06	0,22	0,92	0,32
Full Sample Average	0,03	0,27	0,44	0,30
Full Sample Total (Aggregate Vulnerability)	2,45			

Policy Interventions

- Size cap (€ 500, € 900, € 1300 bn)
  - Bad: contaminates smaller banks
- Debt re-nationalization
  - Good: because GIIPS banks are less levered in our sample
- Merge banks most directly exposed to shock
  - Nothing: our model is scale-free (no ring-fencing effect)
- "Euro-Bond": mix all euro sovereign debt and re-distribute according to initial total sovereign exposure
  - Bad: increases exposure to GIIPS debt of non GIIPS bank (contamination)
- Cap leverage
  - Good: but requires massive rebalancing: 480bn euros to cap leverage @ 15

Optimal Equity Injections

- Suppose we had X billion of euros to distribute in equity to banks, in an effort to stabilize system
  - Constraint: can't take equity from healthy banks
- How would we distribute this capital?
- Optimal injection in given bank strongly correlated with its systemicness (.91)

Extension: Alternative Liquidation Rules

- *Positive* :
  - Banks might liquidate only highly liquid assets because of transactions costs concerns
- *Normative* :
  - Regulation could force banks to commit to liquidation rules, limiting the contagion

- *Example:* Assume banks liquidate ***only sovereigns***

→ **Aggregate Vulnerability of banks to a GIIPS write-down is now 23%, instead of 285%**

- 2 opposite effects:
  - Higher fire-sales of sovereigns
  - Major effect: No contamination of other assets (which are majority)

Conclusion

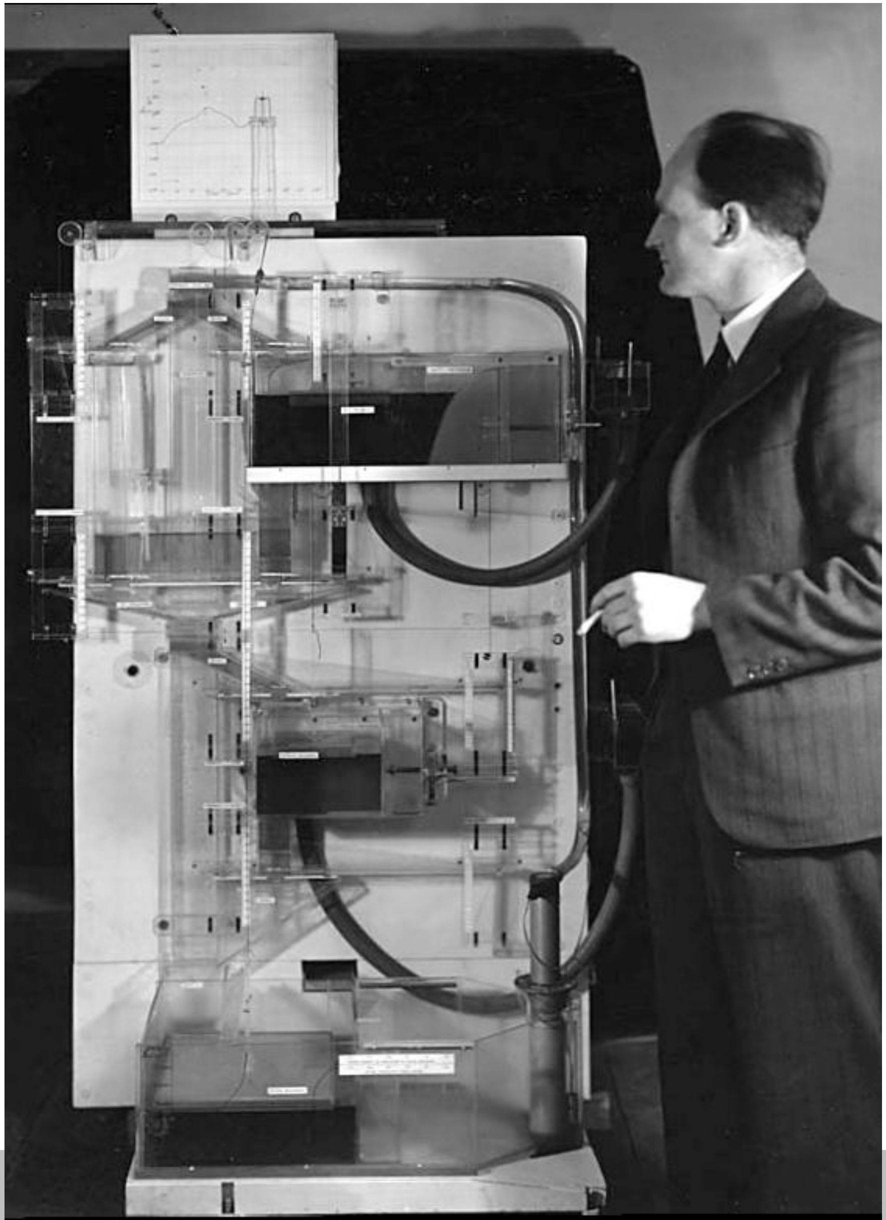
- **Simple framework**
  - Yields several measures and insights about fragility

- **Key contributions** (relative to other measures):
  - Quasi-structural but highly tractable
  - Isolating specific mechanism (fire sale contagion)
  - Able to perform policy experiments
  - Plasticity:
    - Can plug-in more complex liquidation rules
    - Possibility to estimate M matrix from stock returns

- **Limitations & areas for future work**
  - Build in bank optimization problem

- **Regulation**: through liquidation constraints?

Hydraulic models: An ancient tradition in economics



Phillips with his analog computer. Each tank represented some aspect of the UK Economy and the flow of money around the economy was illustrated by coloured water. At the top of the board was a large tank called the treasury. Water flowed from the treasury to other tanks representing the various ways in which a country could spend its money.

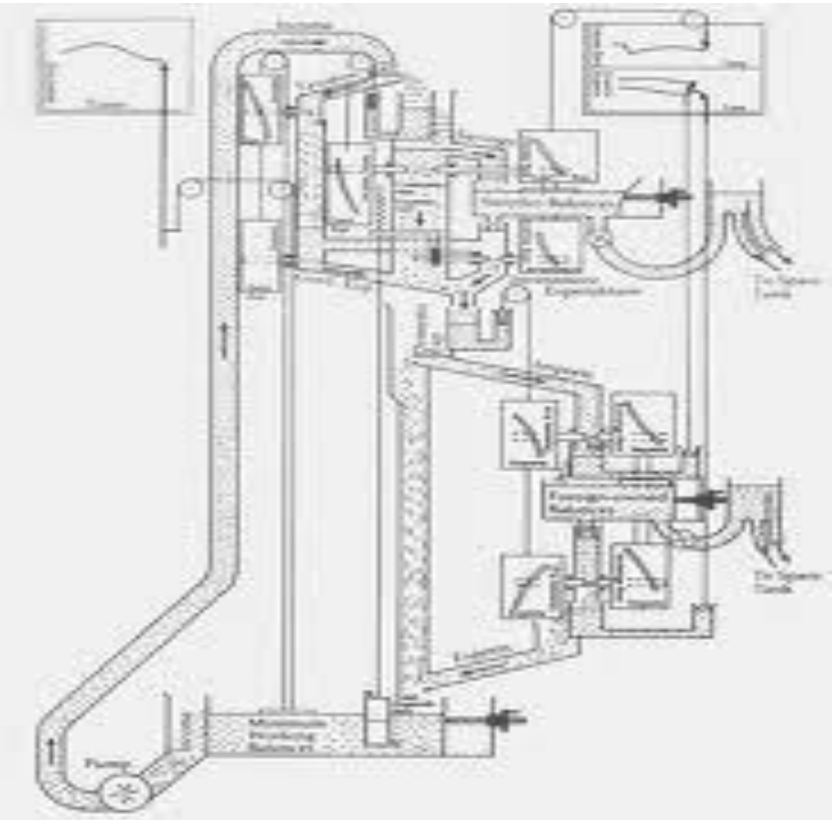


Diagram of the Phillips machine. Source: LSE Quarterly, Winter [illegible], Nick Barr