Liquidity stress test and interbank contagion

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(*) Views expressed in this presentation are those of the authors and do not necessarily reflect the opinions of the Bank of Italy

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Interbank contagion studies

- **Interbank contagion studies**
  - role of direct interbank connections as a source of systemic risk
  - how specific shocks are transmitted throughout the system to gauge the implications for the overall resilience of the banking sector
- **Traditional studies in interbank contagion**
  - typical shock: a given bank's *default* on all of its interbank payments
  - contagion mechanism: once an institution is insolvent, it fails to honor its commitments, which in turn leads to write-offs at its counterparties (*asset-driven contagion*)

    a solvency stress test

    → *no role for liquidity effects in the contagion process (banks can face liquidity problems well before insolvency)*

    no contagion via funding markets and markets for liquid assets held in the counterbalancing capacity
- **Mixed approach (funding risk and solvency risk)**
  - initial shock: increased uncertainty over counterparty risk (solvency risk)
  - contagion mechanism: via funding markets (counterparty risk leads banks and investors to hoard liquidity and reduce funding in the interbank market)

"Modeling Correlated Systemic Liquidity and Solvency Risk in a Financial Environment with Incomplete Information", Barnhill-Schumacher (2011), IMF WP/11/263

"Externalities in interbank network: results from a dynamic simulation model" Manna-Schiavone (2012), Banca d'Italia WP 893

Liquidity contagion models – key issues

In a liquidity contagion model a liquidity shock triggers a liquidity hoarding process which propagates trough the short-term funding network

- **liquidity shock: collateral depreciation**
  - ✓ loss in the market value of liquid assets affects the counterbalancing capacity (CBC)
    - haircuts, market price
    - haircuts and market price should differentiate between asset categories
  - ✓ loss on CBC affects the ability to generate cash-inflows from *unencumbered* liquid assets and decrease the availability of funding due to an increase in collateral requirements for *encumbered* assets

- **propagation mechanism: hoarding**
  - ✓ trigger event: liquidity hoarding
  - ✓ propagation mechanism: through the funding network (liability-driven contagion)

→ *banks are still solvent but are unwilling/unable to provide (further) lending to their counterparties*

- **propagation channel: short-term funding network (liability-driven contagion)**
  - ✓ unsecured interbank relationships (deposits and certificates of deposits)

Liquidity contagion models – motivation/discussion

"Complexity, Concentration and Contagion", Gai-Haldane-Kapadia (2011), Journal of Monetary Economics, 58:5, July

- **Banks' liquidity position and liquidity hoarding**
  - banks must maintain a positive liquidity position; if it becomes negative, banks react immediately to restore it
  - liquidity hoarding
    - ✓ a mitigating action: reducing unsecured interbank lending increases the bank's liquidity position
    - ✓ a propagation factor: a bank calls in interbank loans and decreases other banks' liquidity position, causing other banks in turn to do the same (externality)

- **Why liquidity hoarding?**
  - raise interest rates on wholesale funding has negative signaling implications
  - liquidating fixed assets likely to impose significant costs (fire sales)
  - withdraw own lending to other banks less costly/chosen by banks during the crisis

- **Role of repo market activity and haircut shocks**
  - amplification role of collateral
  - not a contagion factor (ECB full allotment policy; CCP)

The model – data, dynamics, vulnerability factors

- **Bank of Italy's data on interbank exposures and collateral**
  - ✓ real data, full coverage of exposures from bank i to bank j
  - ✓ secured and unsecured market
  - ✓ high granularity: detailed breakdown by instruments and markets
    - detailed information on the counterbalancing capacity (unencumbered and encumbered assets)

- **Contagion dynamics and vulnerability factors**
  - level of liquid asset holdings
  - size of adverse aggregate haircut shocks
  - amount of repo borrowing
  - level of unsecured interbank activity
  - the structure and connectivity of the unsecured interbank network
  - externality vs. mitigating action

Key concepts: the counterbalancing capacity and the liquidity position

$$CBC_i = A_i^L + (1 - h_g)A_i^C - L_i^R$$

CBC_i Counterbalancing capacity of bank *i*

A_i^L Cash, Central bank reserves

A_i^C Assets (unencumbered and encumbered) which may be used as collateral in ECB and/or market repo transactions

L_i^R Repo liabilities (ECB or market)

h_g Haircut, $g = (1,\ldots\ldots,n)$ n = number of asset classes

Liquidity position

cash, central bank reserves +

the amount which may be raised from pledging collateral assets +

the amount raised from re-hypothecating collateral received in reverse repo operations –

its repo liabilities –

outflows due to the liquidity hoarding of counterparties (contagion factor) +

inflows due to own liquidity hoarding (mitigating factor)

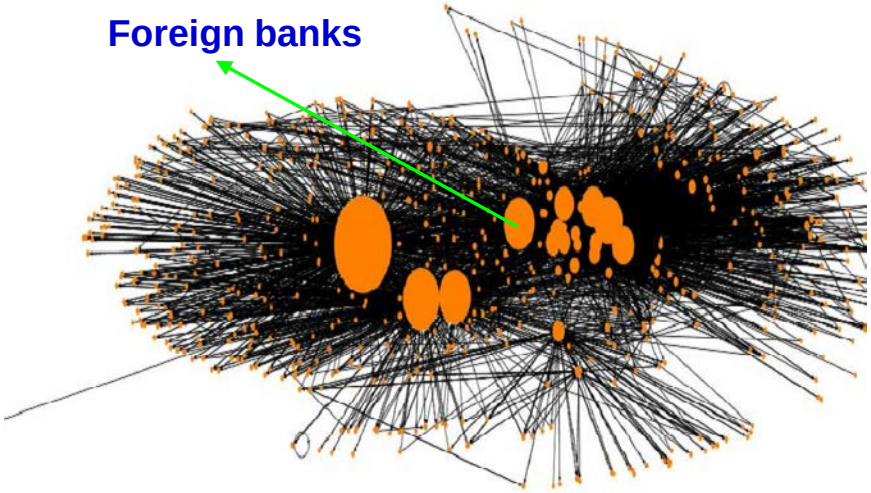
The model – propagation mechanism: the Italian unsecured interbank network (1)

	in-degree	*out-degree*	*degree centrality*	*eigenvector centrality*	*betwenneess centrality*
March 2013					
mean	5,78	5,78	11,56	0,03	0,004
median	1	3	5	0,03	0,0001
25th quantile	1	2	3	0,02	0
75th quantile	2	5	7	0,04	0,0004
Max	355	314	669	0,51	1
Memorandum: Foreign node	127	82	209	0,20	0,0003
March 2011					
mean	5,8	5,8	11,6	0,03	0,005
median	1	3	4	0,02	0,00001
25th quantile	1	2	3	0,02	0
75th quantile	2	5	7	0,03	0,0002
Max	384	217	601	0,28	1
Memorandum: Foreign node	127	91	218	0,26	0,002
March 2009					
mean	5,55	5,55	11,09	0,04	0,003
median	1	2	4	0,02	0
25th quantile	1	2	3	0,02	0
75th quantile	2	4	6	0,03	0,00012
Max	380	305	685	0,34	1
Memorandum: Foreign node	133	77	210	0,22	0,0007

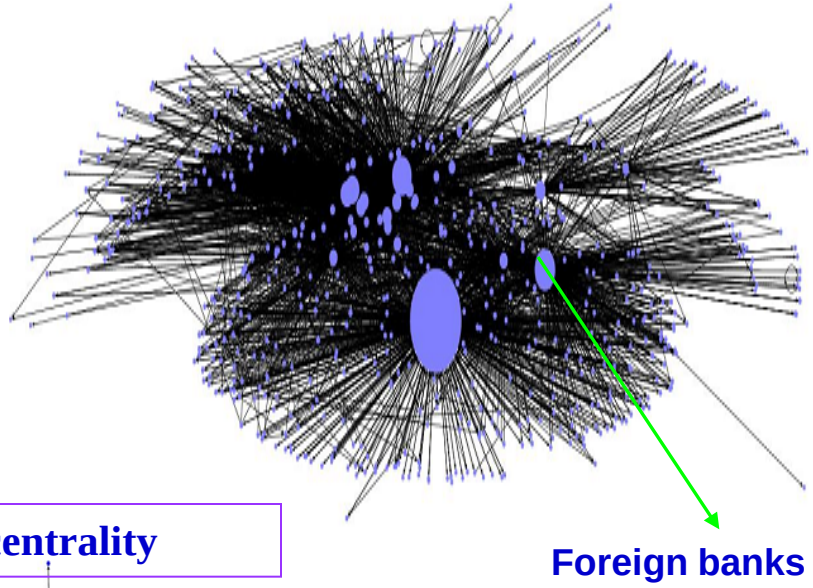
Source: Authors' calculations using Bank of Italy's Supervisory Reports

The Italian unsecured interbank network (2)

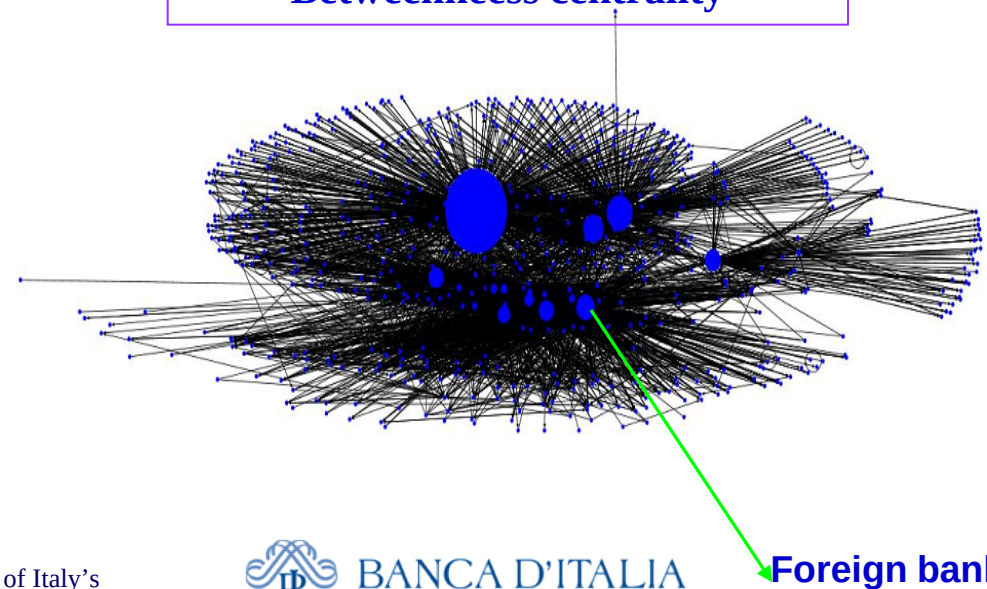
In-degree centrality



Out-degree centrality



Betweenneess centrality



- Density: 0.02
  "small world pattern"
- Some nodes/banks are central

Source: Authors' calculations using Bank of Italy's Supervisory Reports as of March 2013

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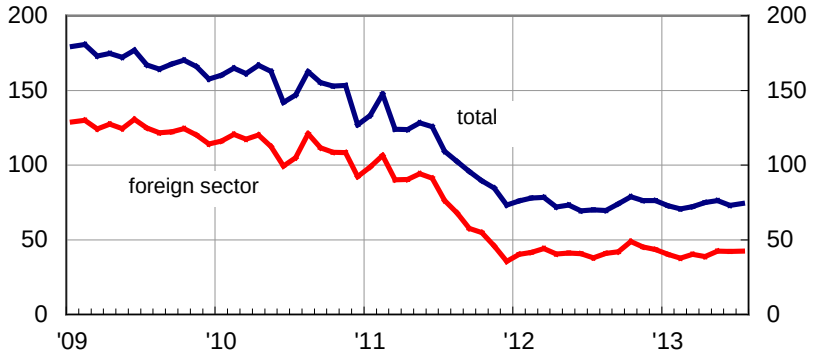
Segments of the Italian interbank market

Short-term unsecured interbank borrowing (1)

(outstanding volumes in billions of euros, end-of-month data)

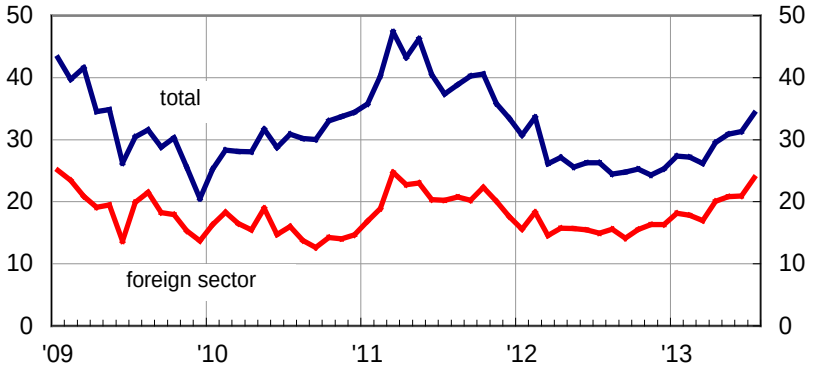


Source: Bank of Italy's Supervisory Reports.

(1) Unsecured transactions with maturity up to two years.

Short-term OTC secured interbank borrowing (1)

(outstanding volumes in billions of euros, end-of-month data)

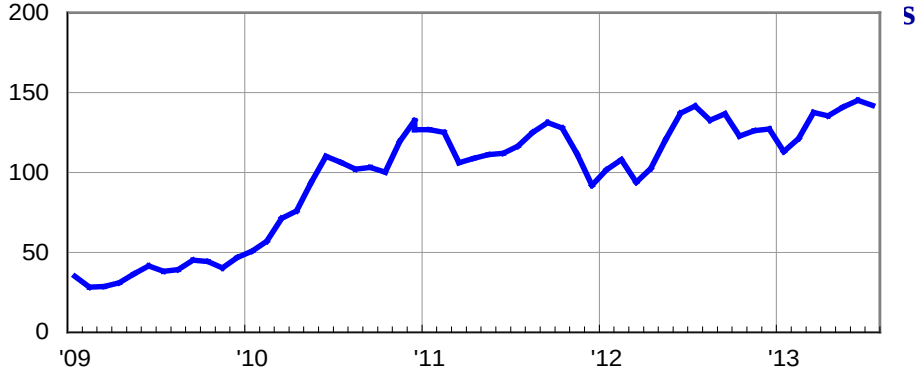


Source: Bank of Italy's Supervisory Reports.

(1) Bilateral repos, non-CCP transactions with maturity up to three months.

Italian banks' debtor position on repo markets

(outstanding exposures in billions of euros, end-of-month data)



Source: calculations based on Bank of Italy / MTS S.p.a. data

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The contagion model in sum

1. **An exogenous shock on the value of collateral**
   - banks face a liquidity shortage due to a depreciation in the collateral value of encumbered (repo, Eurosystem refinancing) and unencumbered assets
   - asset risk/market risk/sovereign risk (link between market risk and liquidity risk)
   - negative impact on the counterbalancing capacity
2. **Propagation through hoarding of liquidity**
   - banks take defensive actions by withdrawing (or, equivalently, refusing to roll over) unsecured interbank assets according to
     - ✓ the size of the negative impact on the counterbalancing capacity
     - ✓ whether the liquidity condition holds or not
3. **The process ends when no "new" bank's liquidity position is negative**

Exogenous shock: Impact on the CBC → **All banks take defensive actions** → **Illiquid banks take defensive actions** → **End of simulation: *n* banks are potentially illiquid**

Liquidity hoarding: externality vs mitigating factor

Banks' reaction function

a. Banks suffering a decline in the CBC withdraw a fraction **λ** of their own unsecured lending to other banks**.** We assume that (based on historical data):

- ✓ foreign banks withdraw all interbank lending (λ=1)
- ✓ domestic banks withdraw all interbank lending if the CBC turns negative otherwise λ< 1

c. Therefore bank ***I*** loses $\boldsymbol{\lambda\, \mu_i L^{IB}_i}$ of its liabilities due to liquidity hoarding by its counterparties in the network (negative externality). It is in turn forced to withdraw its interbank lending if its liquidity condition does not hold

$$CBC_i^{after\_shock} - \underbrace{\lambda \mu_i L_i^{IB}}_{\textbf{externality}} < 0$$

L_i^{IB} unsecured interbank liabilities

d. Bank ***I*** withdraws all its interbank lending: λ_i =1. Hoarding liquidity implies that the bank improves its liquidity position of $\lambda_i A^{IB}_i$ where A^{IB}_i is its unsecured interbank lending

$$CBC_i^{after\_shock} - \lambda \mu_i L_i^{IB} + \underbrace{\lambda_i A_i^{IB}}_{\textbf{mitigating action}}$$

e. Iterations end when no new banks' liquidity position is negative

An exogenous shock on the collateral value – three adverse scenarios

Scenario 1 – Eurosystem eligible collateral

- 1 notch downgrade in the best rating of the Republic of Italy
- a hike in the sovereign spread
- 1 notch downgrade in the Italian banks' best rating
- 1 notch downgrade of Italian banks' ABS and covered bond best rating

Scenario 2 – marketable and high quality collateral

- a hike in the sovereign spread

Scenario 3 – marketable and high quality collateral

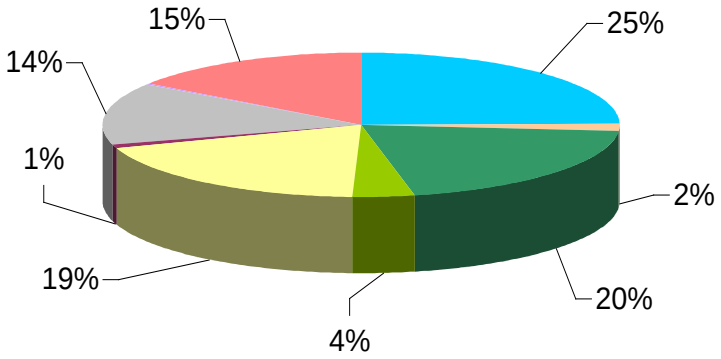
- 1 notch downgrade in the best rating of the Republic of Italy
- hike in the sovereign spread
- an increase in the Central counterparties (CCP) margins

Counterbalancing capacity composition

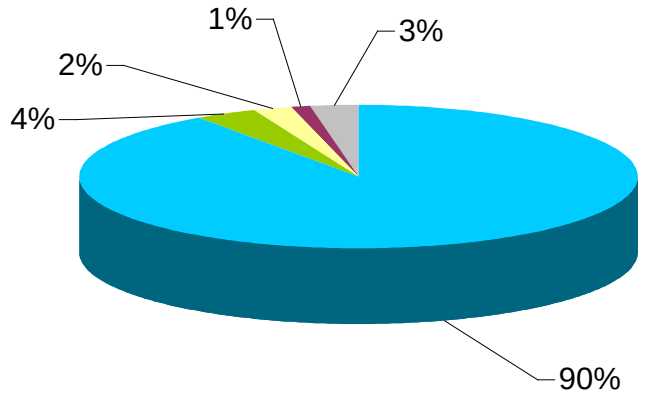
Eligible assets of Italian banks

March 2013

Collateral pool



Other freely avalaible eligible securities



- Central government securities
- Regional government securities
- Government-guaranteed bank bonds
- Uncovered bank bonds
- Covered bank bonds
- Corporate bonds
- ABSs
- Other marketable assets
- Non-marketable assets (bank loans)

Source: calculations using Eurosystem data and Bank of Italy's Supervisory Reports

Exogenous shock on the collateral value – Eurosystem haircuts

Eurosystem collateral framework: haircuts applied to liquidity categories

(percentages)

		Liquidity category I			*Liquidity category II*			*Liquidity category III*			*Liquidity category IV*			*Liquidity category V (*)*		
Credit quality	Residual maturity (years)	Fixed coupon	Zero coupon	Variable coupon	Fixed coupon	Zero coupon	Variable coupon	Fixed coupon	Zero coupon	Variable coupon	Fixed coupon	Zero coupon	Variable coupon	Fixed coupon	Zero coupon	Variable coupon
[AAA : A-]	0-1	0.5	0.5	0.5	1.0	1.0	1.0	1.5	1.5	1.5	6.5	6.5	6.5	16.0	16.0	16.0
	1-3	1.5	1.5	0.5	2.5	2.5	1.0	3.0	3.0	1.5	8.5	9.0	6.5	16.0	16.0	16.0
	3-5	2.5	3.0	0.5	3.5	4.0	1.0	5.0	5.5	1.5	11.0	11.5	6.5	16.0	16.0	16.0
	5-7	3.0	3.5	0.5	4.5	5.0	1.0	6.5	7.5	1.5	12.5	13.5	6.5	16.0	16.0	16.0
	7-10	4.0	4.5	0.5	5.5	6.5	1.0	8.5	9.5	1.5	14.0	15.5	6.5	16.0	16.0	16.0
	>10	5.5	8.5	0.5	7.5	12.0	1.0	11.0	16.5	1.5	17.0	22.5	6.5	16.0	16.0	16.0
[BBB+ : BBB-]	0-1	5.5	5.5	5.5	6.0	6.0	6.0	8.0	8.0	8.0	15.0	15.0	15.0	26.0	26.0	26.0
	1-3	6.5	6.5	5.5	10.5	11.5	6.0	18.0	19.5	8.0	27.5	29.5	15.0	26.0	26.0	26.0
	3-5	7.5	8.0	5.5	15.5	17.0	6.0	25.5	28.0	8.0	36.5	39.5	15.0	26.0	26.0	26.0
	5-7	8.0	8.5	5.5	18.0	20.5	6.0	28.0	31.5	8.0	38.5	43.0	15.0	26.0	26.0	26.0
	7-10	9.0	9.5	5.5	19.5	22.5	6.0	29.0	33.5	8.0	39.0	44.5	15.0	26.0	26.0	26.0
	>10	10.5	13.5	5.5	20.0	29.0	6.0	29.5	38.0	8.0	39.5	46.0	15.0	26.0	26.0	26.0

(*) CMBS in [BBB+ : BBB-]: haircut 32%

Exogenous shock on the collateral value – CCP margins

Margins applied by LCH SA (and Cassa Compensazione e Garanzia) on Italian government securities

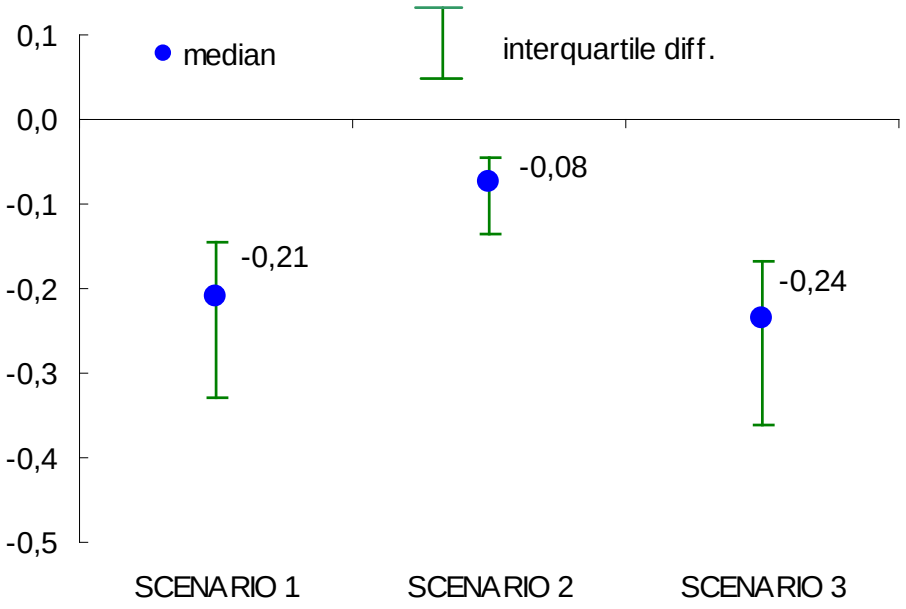
(percentages)

Buckets	October 2011	November 2011	Change vs. the previous decision	March 2013
(0-1m)	0,70	4,20	3,50	0,70
(1-3m)	1,00	4,50	3,50	1,10
(3-9m)	2,40	6,40	4,00	3,10
(0.75-1.25y)	2,45	6,45	4,00	3,60
(1.25y-2y)	2,50	6,50	4,00	3,80
(2y-3.25y)	3,15	7,15	4,00	5,55
(3.25y-4.75y)	4,20	8,70	4,50	7,25
(4.75-7y)	4,95	9,45	4,50	9,30
(7-10y)	6,65	11,65	5,00	11,65
(10y-15y)	6,80	11,80	5,00	12,00
(15-30y)	15,00	20,00	5,00	20,00
(30-50)				
BTP€i	9,00	14,00	5,00	15,85

Results - impact of the exogenous shock

Post- scenario relative change in the counterbalancing capacity

(data as of March 2013)



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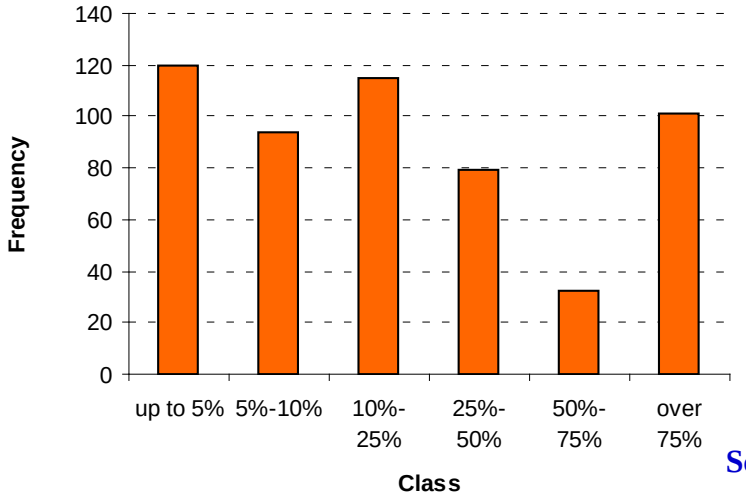
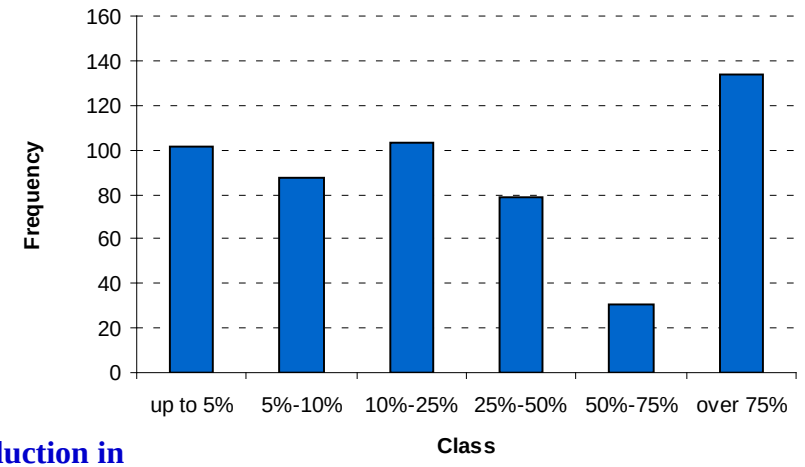
Simulation results - impact of contagion

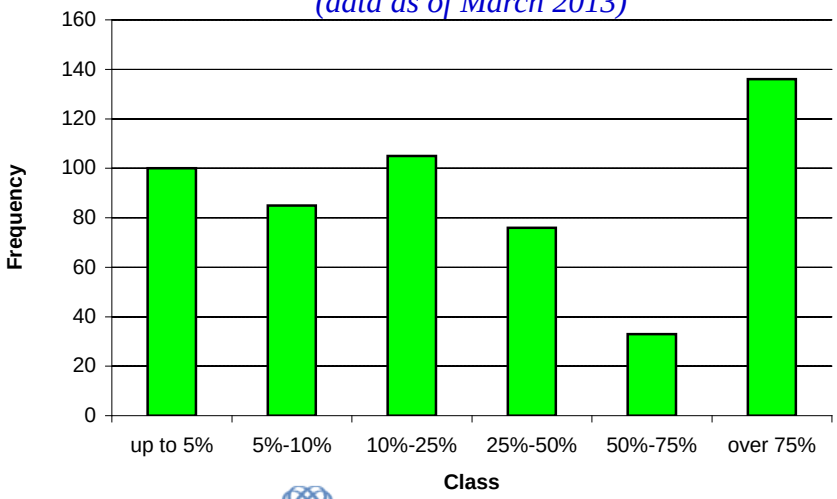
Scenario 1: percent reduction in interbank borrowing
(data as of March 2013)



Scenario 2: percent reduction in interbank borrowing
(data as of March 2013)



Scenario 3: percent reduction in interbank borrowing
(data as of March 2013)



In case of severe stress, liquidity hoarding has a potentially significant impact on the size and the depth of the interbank unsecured market

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Simulation results – impact of the mitigating factor

- Liquidity hoarding is an effective mitigating action for restoring a positive liquidity position for banks affected by a severe shock on the value of their assets
- At the system level, the mitigating action outweighs the contagion factor
- A very small fraction of banks would end-up being potentially illiquid at the end of the simulation runs; in most cases, hording liquidity turns after-shock potentially illiquid banks into liquid banks
- At the end of the simulation runs, in no cases the contagion factor turns potentially liquid into potentially illiquid banks
- A robust network: even under very adverse scenarios and a strict definition of liquid assets, the Italian interbank system would be resilient to the combination of market/sovereign risk and liquidity risk

Conclusions

- Gay-Kapadia (2010), Haldane (2009)
  - ✓ highly interconnected financial networks may be “robust-yet-fragile” in the sense that “within a certain range, connections serve as shock-absorbers and connectivity engenders robustness”

- The combination of some crucial factors drives the result
  - ✓ the level of unsecured borrowing
  - ✓ the structure and connectivity of the network
  - ✓ assumptions about the banks’ reaction functions

- Robustness tests
  - ✓ different reaction functions
  - ✓ …