CORRELATION NETWORKS TO MEASURE THE SYSTEMIC IMPLICATIONS OF BANK RESOLUTION

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Disclaimer: *Laura Parisi is currently affiliated to the ECB, however the paper was written while she was working at the University of Pavia. The paper represents the authors' personal opinions and does not necessarily reflect the views of the institutions with which they are affiliated.*

RESEARCH PROBLEM

- A key component of systemic risk is the **probability of default** of financial institutions.
- Default probabilities can be calculated using market-based data (e.g. CDS spreads), or by looking at the balance-sheet structure of banks.
- This paper: from a **micro-** to a **systemic** approach.
  Default probability of each financial institution $\longrightarrow$ Joint default probability of the entire financial system.
- FOLTF banks can be subject to different resolution decisions.

Objective

What would happen to each single bank, and to the entire banking system, in case an adverse scenario materialises, taking into account the regulatory BRRD/SRM context established in the Euro area.

- Market-based data + micro-data + systemic risk tools;

- Consequences of banks resolution
  - at the bank level
  - at the system level

PAPER IN A NUTSHELL

▶ We define a risk measure for each single bank (based on CDS spreads);

▶ We find one or more financial institutions under distress (assumed to be FOLTF);

▶ We derive the consequences of having FOLTF banks in the system according to two perspectives:

  ▶ for each single financial institution,
  ▶ for the entire banking system;

▶ and under three alternative scenarios:

  ▶ FOLTF banks are liquidated,
  ▶ FOLTF banks are recapitalised through a private intervention,
  ▶ FOLTF banks are subject to bail-in resolution;

▶ We compare the consequences (measured in terms of expected losses) under the three scenarios and according to the two perspectives, in order to identify the "best" resolution decision as the one that minimises losses.

SYSTEMIC RISK IN THE BANKING SECTOR: LITERATURE OVERVIEW

1. Conditional quantiles:
   - Acharya et al. (2010), Adrian & Brunnermeier (2011), Brownlees & Engle (2012)
   - Identify SIFIs ⟶ Do not describe contagion transmission;

2. Regression methods:
   - Koopman et al. (2012), Betz et al. (2014), Duprey et al. (2015), Hautsch et al. (2015)
   - Provide predictive models ⟶ Do not describe contagion transmission;

3. Network models:
   - Battiston et al. (2012), Billio et al. (2012), Minou and Reyes (2013), Diebold and Ylmaz (2014)
   - Describe contagion transmission ⟶ Do not provide predictive models.

Our contribution

- Systemic risk measure based on CDS spreads;
- Contagion mechanism based on partial correlation networks.

BANKS RESOLUTION IN THE EURO AREA: OVERVIEW

- ▶ ECB (or SRB in exceptional circumstances) identifies a bank as FOLTF;
- ▶ SRB identifies the resolution strategy;
- ▶ FOLTF bank is **not systemically important** → liquidation;
- ▶ FOLTF bank is **systemically important** → Bail-in
  - ▶ waterfall hierarchy of bail-inable resources to cover losses,
  - ▶ consequences on private creditors rather than on taxpayers.
- ▶ IF and ONLY IF two conditions are met:
  - ▶ no alternative private interventions would prevent the failure of the FOLTF bank,
  - ▶ bail-in is necessary in the public interest.

Our contribution

Comparison between the expected losses (for each bank and for the entire system) in case of:

- ▶ liquidation,
- ▶ private intervention (recap),
- ▶ bail-in.

BACKGROUND
oooo

METHODOLOGY
●ooo

SIMULATION EXERCISE
ooo

APPLICATION
ooooo

CONCLUSION
ooo

APPENDIX
ooo

MEASURING SYSTEMIC RISK

Univariate EL

From CDS spreads of financial institutions.

+

Contagion effect

From the partial correlation network between the CDS spreads of financial institutions.

=

Multivariate EL

Can be used to assess contagion between financial institutions, for example in the BRRD context.

THE BANKS' PERSPECTIVE

▶ Let A be a vector of (net) asset values: $A = \{A_1, \ldots, A_N\}$.

$$EL_n = A_n \cdot (PD_n) \cdot (1 - RR_n).$$

▶ Let S_n be the CDS spread: in the simplified case of a one-year contract

$$EL_n = A_n \cdot S_n,$$

▶ We extend EL_n into a multivariate expected loss (TEL) that takes contagion between CDS spreads into account:

Multivariate EL

$$TEL_n = EL_n + \sum_{m \neq n} c_{mn|rest} EL_m, \qquad [rest = V \setminus \{m, n\}]$$

▶ The geometric average between the coefficients is equal to the partial correlation between EL_m and EL_n:

$$|\rho_{mn|rest}| = |\rho_{nm|rest}| = \sqrt{c_{mn|rest} \cdot c_{nm|S}}.$$

BACKGROUND
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METHODOLOGY
○○●○

SIMULATION EXERCISE
○○○

APPLICATION
○○○○○

CONCLUSION
○○○

APPENDIX
○○○

THE SYSTEM'S PERSPECTIVE

$$TEL^{system} = \left[\sum_{i=1}^{N} A^i\right] \cdot \left[Pr\left(\bigcap_{i=1}^{N} D^i\right)\right] =$$

$$= \left[\sum_{i=1}^{N} A^i\right] \cdot \left[Pr(D^1) \cdot Pr(D^2|D^1) \cdot \dots \cdot Pr(D^N|D^1, D^2, \dots, D^{(N-1)})\right].$$

TEL^{system}
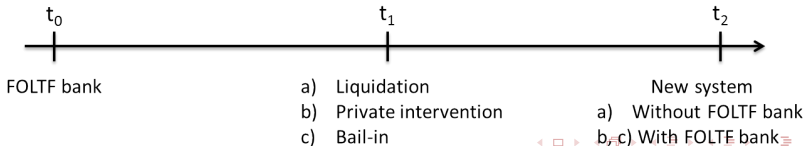
$$TEL^{system} = \left[\sum_{i=1}^{N} A^i \cdot \prod_{i=1}^{N} PD^i\right] +$$

$$+ \left[\sum_{i=1}^{N} A^i \cdot \sum_{\omega, \omega_1, \omega_2} \left(\prod_{\omega=1}^{N(N+1)/2} \rho_\omega \prod_{\omega_1=1}^{N} PD^{\omega_1} \prod_{k \neq \omega_2} PD^k \prod_{\omega_1, \omega_2=1}^{N} \frac{A^{\omega_1}}{A^{\omega_2}}\right)\right] =$$

$$= TEL^{system,1} + TEL^{system,2}.$$

BACKGROUND
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METHODOLOGY
ooo●

SIMULATION EXERCISE
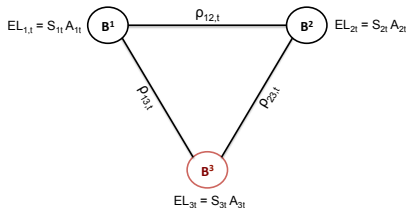ooo

APPLICATION
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CONCLUSION
ooo

APPENDIX
ooo

THE EFFECTS OF BANKS RESOLUTION

- ▶ **ASSUMPTION**: one bank (B^m) is identified as FOLTF.
- ▶ **QUESTION**: does another bank (B^n) in the system prefer B^m to be liquidated, recapitalised (private intervention) or subject to bail-in?
- ▶ Each bank should evaluate the consequences of the three alternative scenarios in a long-run perspective.
- ▶ We aggregate the expected losses over time (survival analysis).
- ▶ The preferred scenario is the one that minimises the expected losses of:
  - ▶ each single bank (banks' perspective),
  - ▶ the entire banking system (system's perspective).
- ▶ Discrete time-line

t_0 t_1 t_2

FOLTF bank

a) Liquidation
b) Private intervention
c) Bail-in

New system
a) Without FOLTF bank
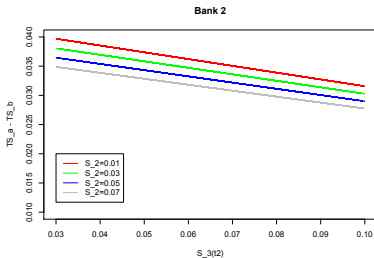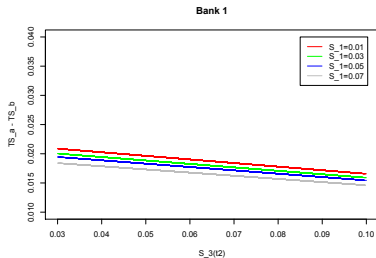b) c) With FOLTF bank

EXAMPLE: THREE BANKS

$A_1=40$ bn €, $A_2=20$ bn €, $A_3=4$ bn €

$S_n \sim \mathcal{N}(\mu_{S_n}, \sigma_{S_n}^2)$ with $\mu_{S_1}, \mu_{S_2} = 0.01, 0.03, 0.05, 0.07$ and unit variances

$\rho_{mn} \sim \mathcal{N}(\mu_{\rho_{mn}}, \sigma_{\rho_{mn}}^2)$ with $\mu_{\rho_{12}}, \mu_{\rho_{13}}, \mu_{\rho_{23}} \sim \mathcal{U}([-0.5, 0.5])$

$$\begin{cases} S_{3,t_j} \sim \mathcal{N}(\mu_{S_{3,t_j}}, \sigma_{S_3}^2), \\ \mu_{S_{3,\{t_0,t_1\}}} = 0.10, \\ \mu_{S_{3,t_2}} \sim \mathcal{U}([0, 0.30]), \end{cases} \tag{1}$$

Paolo Giudici & Laura Parisi

BACKGROUND
oooo

METHODOLOGY
oooo

SIMULATION EXERCISE
o●o

APPLICATION
ooooo

CONCLUSION
ooo

APPENDIX
ooo

SIMULATION RESULTS 1

▶ The private intervention always minimises losses in case of positive correlations;

▶ This effect is even stronger for smaller and safer (lower PD) banks.

SIMULATION RESULTS 2
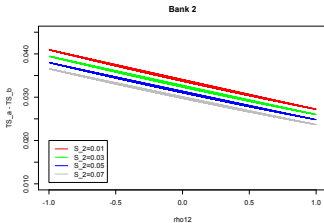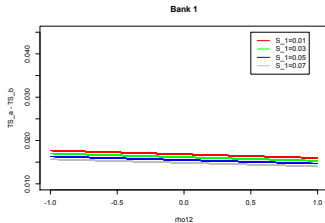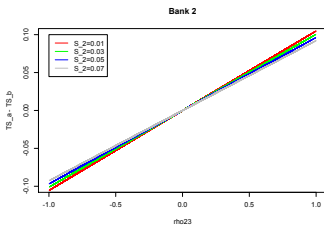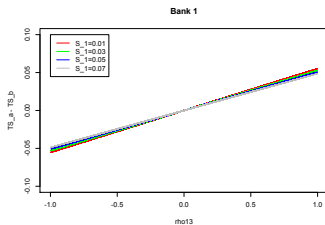
DATA: CDS SPREADS AND SIZE OF ITALIAN BANKS

Bank	μ (%)	Max (%)	Min (%)	σ ($\cdot 10^{-2}$)
MPS	**7.321**	**8.836**	**3.714**	**1.429**
BPM	3.318	4.043	2.168	0.456
BAPO	3.771	4.871	2.608	0.484
MB	2.250	3.081	1.601	0.351
UCG	1.430	1.584	1.292	0.097
UBI	2.915	3.417	2.067	0.354
ISP	1.693	2.395	1.168	0.291

Bank	Asset
MPS	**9.58**
BPM	4.44
BAPO	6.92
MB	8.08
UCG	48.00
UBI	7.63
ISP	41.06

PARTIAL CORRELATION NETWORK

Node dimension=Assets
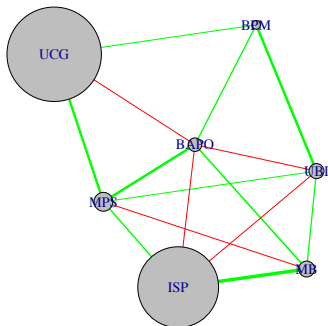
Node dimension=CDS spreads
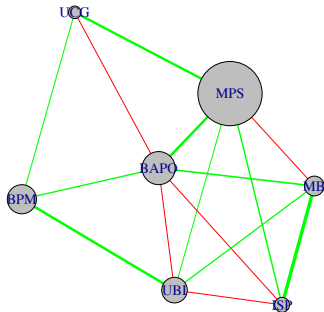
SYSTEM'S VIEW ON MPS DISTRESS (1/3)

▶ Within the sample considered, MPS has the highest riskiness indicator according to our measure of distress;

▶ MPS thus assumed to be the FOLTF bank in our system.

Aggregation over time

SYSTEM'S VIEW ON MPS DISTRESS (2/3)

BACKGROUND
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METHODOLOGY
oooo

SIMULATION EXERCISE
ooo

APPLICATION
ooooo●

CONCLUSION
ooo

APPENDIX
ooo
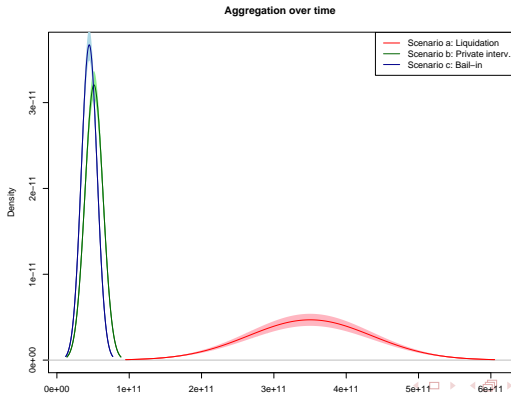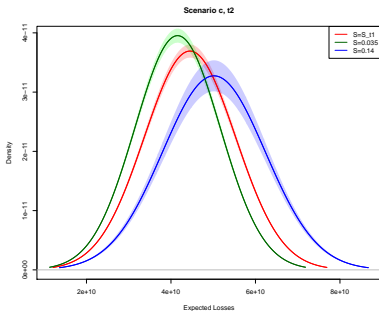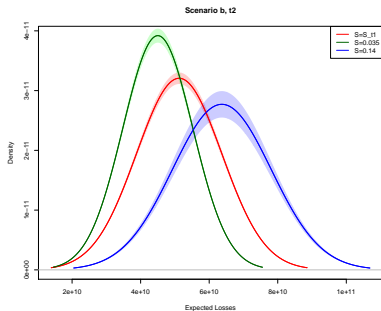
SYSTEM'S VIEW ON MPS DISTRESS (3/3)

Scenario b – Scenario c, t2

CONCLUSIONS
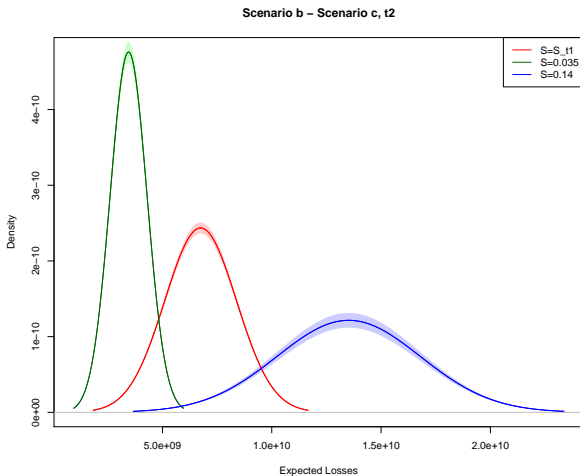
▶ **Banks' perspective:**

  ▶ The smaller or the safer a bank is, the bigger the reduction of EL in case of private intervention,

  ▶ Liquidation reduces EL only in case of strong negative partial correlations,

  ▶ The reduction of EL in case of private intervention is

    ▶ a decreasing function of the PDs of the safe banks,

    ▶ an increasing function of the correlations between safe banks and the FOLTF one.

▶ **System's perspective:**

  ▶ Private intervention and bail-in minimise losses,

  ▶ Bail-in resolution slightly reduces contagion effects with respect to private intervention,

  ▶ An increase in the PD of the FOLTF bank after bail-in/private intervention increases EL of the entire system,

  ▶ Such increase is stronger for the private intervention scenario.

CAVEATS

▶ Proxies for bail-inable liabilities and interbank exposures (no confidential data);

▶ Not considered alternatives such as bridge banks, extraordinary public bail-out/precautionary recap, ...;

▶ No macroeconomic impact of the three scenarios $\longrightarrow$ no effects on taxpayers, or sovereigns-banks loop;

▶ Static approach (time dimension introduced only in the form of three steady states).

Thank you for your attention!

LIQUIDATION

		t_0	t_1	t_2
	B^1	A_1	$A_1 - f_1 \cdot k[A_3 - \text{Eq}_3]$	$A_1 - f_1 \cdot k[A_3 - \text{Eq}_3]$
Assets	B^2	A_2	$A_2 - f_2 \cdot k[A_3 - \text{Eq}_3]$	$A_2 - f_2 \cdot k[A_3 - \text{Eq}_3]$
	B^3	A_3	A_3	-
	B^1	S_1	S_1	S_1
S	B^2	S_2	S_2	S_2
	B^3	S_{3,t_0}	$S_{3,t_1} = 1$	-
	B^1			
Marg. Corr.	B^2	R_{t_0} (3×3)	R_{t_0} (3×3)	R_{t_2} (2×2)
	B^3			
	B^1			
Part. Corr.	B^2	$[(R_{t_0})^{-1}]_{mn} = \rho_{mn|S}$	$[(R_{t_0})^{-1}]_{mn} = \rho_{mn|S}$	$[(R_{t_2})^{-1}]_{mn} = \rho^a_{mn|S,t_2}$
	B^3			

A_i = Net asset values
$Eq._i$ = Equity
$f_i, k \in [0, 1]$

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PRIVATE INTERVENTION

		t_0	t_1	t_2
Assets	B^1	A_1	$A_1(1 - \frac{X}{A_1+A_2})$	$A_1(1 - \frac{X}{A_1+A_2})$
	B^2	A_2	$A_2(1 - \frac{X}{A_1+A_2})$	$A_2(1 - \frac{X}{A_1+A_2})$
	B^3	A_3	$A_3 + X$	$A_3 + X$
S	B^1	S_1	S_1	S_1
	B^2	S_2	S_2	S_2
	B^3	S_{3,t_0}	S_{3,t_0}	S_{3,t_2}
Marg. Corr.	B^1			
	B^2	R_{t_0} (3×3)	R_{t_0} (3×3)	R_{t_0} (3×3)
	B^3			
Part. Corr.	B^1			
	B^2	$[(R_{t_0})^{-1}]_{mn} = \rho_{mn\|S}$	$[(R_{t_0})^{-1}]_{mn} = \rho_{mn\|S}$	$[(R_{t_0})^{-1}]_{mn} = \rho_{mn\|S}$
	B^3			

$X =$ amount needed by B^3 in order to absorb losses still meeting regulatory requirements (Pillar 1)

BAIL-IN

		t_0	t_1	t_2
	B^1	A_1	$A_1 - f_1 \cdot k \cdot$ Bail-in$_3$	$A_1 - f_1 \cdot k \cdot$ Bail-in$_3$
Assets	B^2	A_2	$A_2 - f_2 \cdot k \cdot$ Bail-in$_3$	$A_2 - f_2 \cdot k \cdot$ Bail-in$_3$
	B^3	A_3	$A_3 -$ Bail-in$_3$	$A_3 -$ Bail-in$_3$
	B^1	S_1	S_1	S_1
S	B^2	S_2	S_2	S_2
	B^3	S_3	S_3	S_3
	B^1			
Marg. Corr.	B^2	R_{t_0} (3×3)	R_{t_0} (3×3)	R_{t_0} (3×3)
	B^3			
	B^1			
Part. Corr.	B^2	$[(R_{t_0})^{-1}]_{mn} = \rho_{mn|S}$	$[(R_{t_0})^{-1}]_{mn} = \rho_{mn|S}$	$[(R_{t_0})^{-1}]_{mn} = \rho_{mn|S}$
	B^3			

Bail-in$_3$ = amount of bail-inable liabilities that have to be written down/converted to allow B^3 to absorb losses still meeting regulatory requirements (Pillar 1)
$f_i, k \in [0, 1]$