Correlation networks to measure the systemic implications of banks resolution

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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.
- From a **micro**- to a **macro-prudential** approach: Default probability of each financial institution $\longrightarrow$ 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 + micro-prudential + macro-prudential 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 (FOLTF);
- We derive the consequences of having such 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 "saved" by 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 $\longrightarrow$ 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 $\longrightarrow$ 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 $\longrightarrow$ 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 identifies a bank as FOLTF;
- the bank is **not systemically important** → liquidation;
- the bank is **systemically important** → Bail-in = solution covering losses
  - waterfall hierarchy of bail-inable resources,
  - 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,
  - resolution 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,
- bail-in.

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: $A = \{A_1, \dots, A_N\}$.

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

- 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

$$TEL_n = EL_n + \sum_{m \neq n} c_{mn|rest} EL_m,$$

where $rest = V \setminus \{m, n\}$.

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

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

The system's perspective

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

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

TEL^{system}

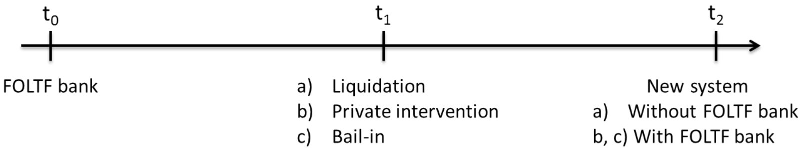
$$TEL^{system} = \left[\sum_{i=1}^{N} A^i \cdot \prod_{i=1}^{N} PD^i\right] +$$

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

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

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, "saved" through a 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 the minimises the expected losses of:
  - each single bank (banks' perspective),
  - the entire banking system (system's perspective).
- Discrete time-line



Liquidation

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

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

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 B^3	R_{t_0} (3×3)	R_{t_0} (3×3)	R_{t_0} (3×3)
Part. Corr.	B^1 B^2 B^3	$[(R_{t_0})^{-1}]_{mn} = \rho_{mn\|S}$	$[(R_{t_0})^{-1}]_{mn} = \rho_{mn\|S}$	$[(R_{t_0})^{-1}]_{mn} = \rho_{mn\|S}$

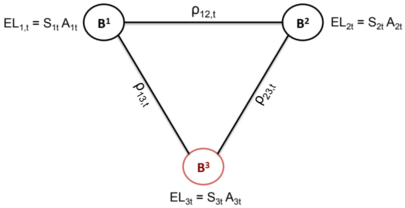
X $=$ amount needed by B^3 in order to absorb losses still meeting regulatory requirements (Pillar 1)

Bail-in

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

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

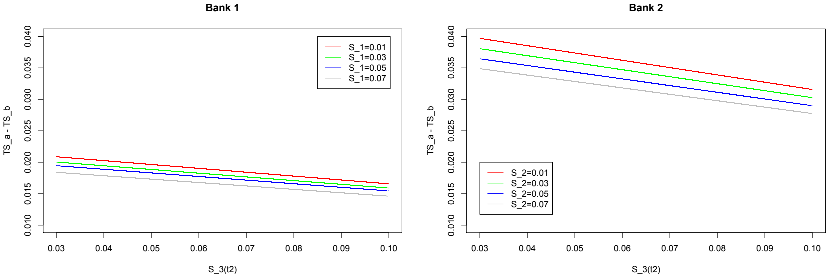
Example: three banks



A_1=40 bn €, A_2=20 bn €, A_3=4 bn €
$S_n \sim \mathcal{N}(\mu_{S_n}, \sigma^2_{S_n})$ with $\mu_{S_1}, \mu_{S_2} = 0.01, 0.03, 0.05, 0.07$ and unit variances
$\rho_{mn} \sim \mathcal{N}(\mu_{\rho_{mn}}, \sigma^2_{\rho_{mn}})$ with $\mu_{\rho_{12}}, \mu_{\rho_{13}}, \mu_{\rho_{23}} \sim \mathcal{U}([-0.5, 0.5])$

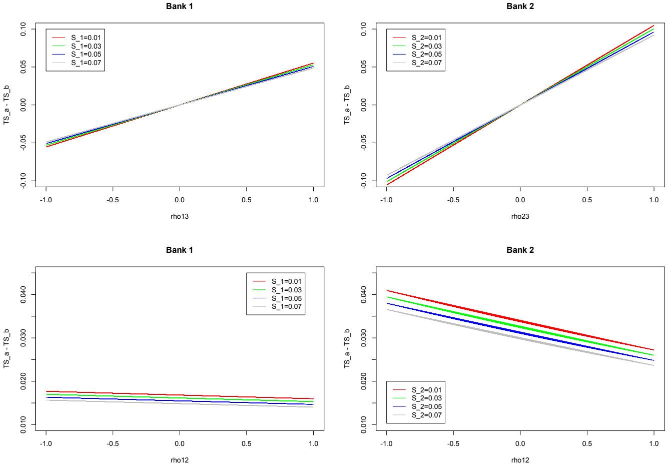
$$\begin{cases} S_{3,t_j} \sim \mathcal{N}(\mu_{S_{3,t_j}}, \sigma^2_{S_3}), \\ \mu_{S_{3,\{t_0,t_1\}}} = 0.10, \\ \mu_{S_{3,t_2}} \sim \mathcal{U}([0, 0.30]), \end{cases} \tag{1}$$

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



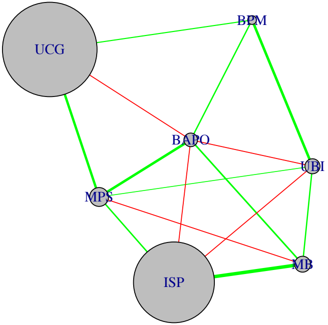
Data: NAV of main Italian banks

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

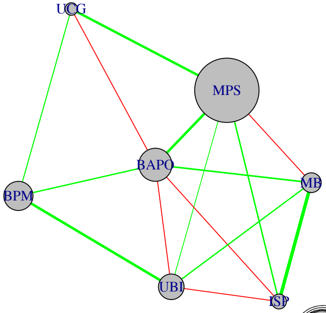
Bank	Asset
MPS	**9.58**
BPM	4.44
BAPO	6.92
MB	8.08
UCG	48.00
UBI	7.63
ISP	41.06

Partial correlation network

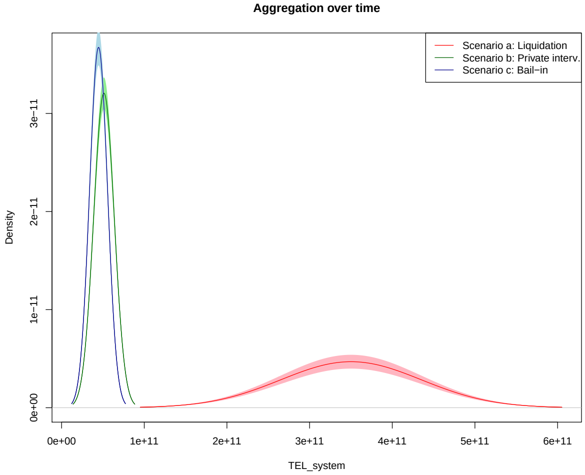
Node dimension=Assets



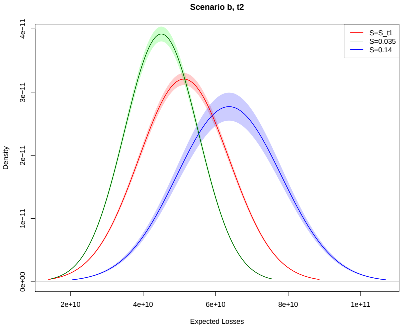
Node dimension=CDS spreads

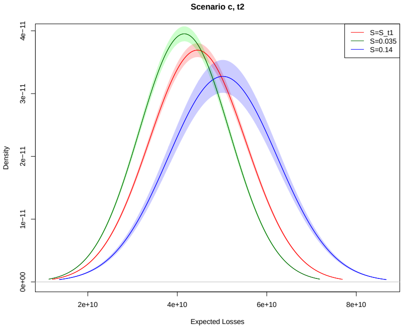


System's view on MPS distress (1/3)

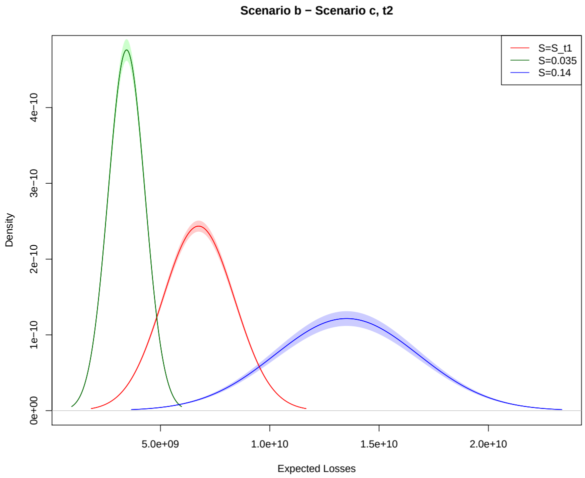


System's view on MPS distress (2/3)





System's view on MPS distress (3/3)



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 intervetnion 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, ...,
- No macroeconomic impact of the three scenarios *longrightarrow* no effects on taxpayers, or sovereigns-banks loop,
- Static approach.