Credit Market Spillovers: Evidence from a Syndicated Loan Market Network

A. Gupta [1] S. Kokas [1] A. Michaelides [2]

[1] University of Essex

[2] Imperial College London, CEPR

XII Annual Seminar on Risk, Financial Stability and Banking of the Banco Central do Brasil, August 10, 2017

Brief review

- Can financial networks generate co-movements in rates and quantities?
- We use the syndicated loan market to construct simultaneous loan network interactions and characterize the network's evolution over time.
- We find economically large and time-varying spillovers from the network to lending rates and quantities that can switch sign after a major economic shock.
- We also find evidence for network complexity and uncertainty rising after large negative shock. Counter-factual experiments confirm importance of spillovers.

Financial architecture and systemic risk

- The banking system is highly interconnected.
- Recent theoretical work by Acemoglu et al., (2015; 2016) stresses the importance of magnitude of shocks on network stability:
  - If shocks are small, network is stable as in Allen and Gale (2000) and Freixas at el. (2000)
  - If shocks are large or numerous, network breaks down as in Blume et al. (2011)
- Their results clarify that increasing the size or the number of shocks reverses the role of network.
- "Robust-Yet-Fragile" (Haldane, 2009)

Motivation

- The literature investigates the existence of networks, but the evolution and the structure of these networks are not well understood.
- Also, limited empirical structural analysis on how network structure affects the real economy.
- Empirical work is partly hampered by the difficulty in building an empirical financial network:
  1. Financial linkages are difficult to obtain or construct.
  2. Network construction is computationally challenging.
  3. Difficulties in identifying channel dependence that arises from simultaneity.

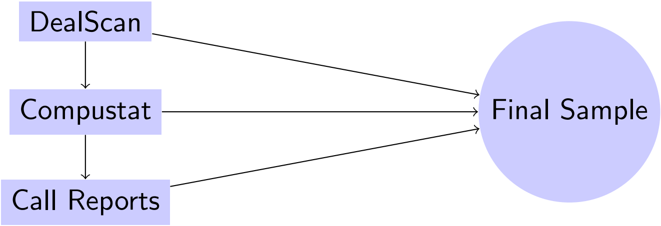
Goals

We ask the following questions:

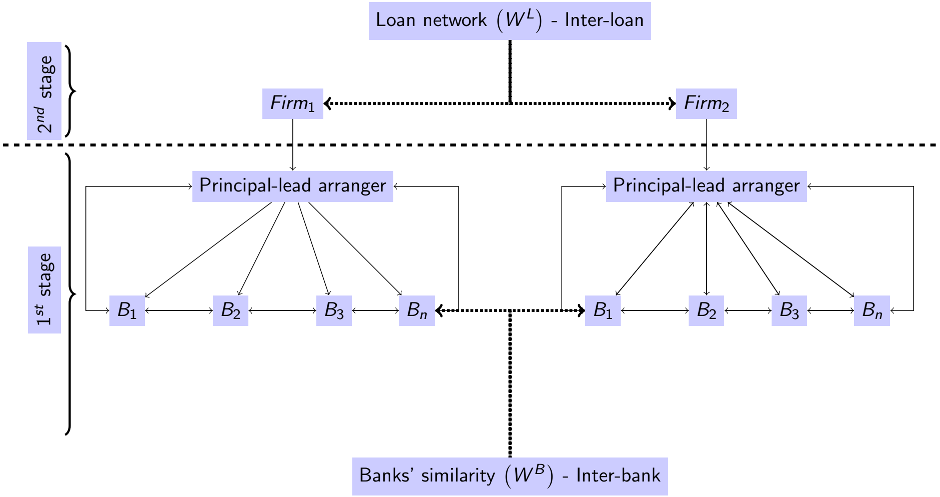
- How can we measure a financial-loan network?
- How can we characterize the evolution of the financial-loan network?
- How can we quantify the potential effect of financial network structure on loan lending rates and quantities?

Data

We construct a data set of syndicated loans in the U.S. market from 1987 - 2016 using three data sources



Syndicated structure



Example

Panel A: Banks' participation per loan			
	Loan ℓ_1	Loan ℓ_2	Loan ℓ_3
Banks:	JPM	JPM	JPM
	C	BoA	C

Panel B: Matrix for banks' similarities			
	JPM	BoA	C
JPM	1		
BoA	0.6592	1	
C	0.4818	0.3749	1

Panel C: Matrix for loan interconnectedness			
	Loan ℓ_1	Loan ℓ_2	Loan ℓ_3
Loan ℓ_1	$w_{1,1}$ =0		
Loan ℓ_2	$w_{2,1}$ =0.6290	$w_{2,2}$ =0	
Loan ℓ_3	$w_{3,1}$ =0.8272	$w_{3,2}$ =0.6290	$w_{3,3}$ =0

In Panel A, we hypothesize banks' participation decision with equal shares for JPM, BoA and C, which where the top 3 U.S. lead arranger in 2015. So, loan ℓ_1 consists from JPM and C, similar for loan ℓ_1 and ℓ_1. In Panel B, we show bank similarities from step 1. In Panel C, we show the loan interconnectedness. Loan interconnectedness between loan ℓ_1 and loan ℓ_2 ($w_{2,1}$) is equal to [(JPM,JPM)+(JPM,BoA)+(C,JPM)+(C,BoA)]/4 = 0.6290.

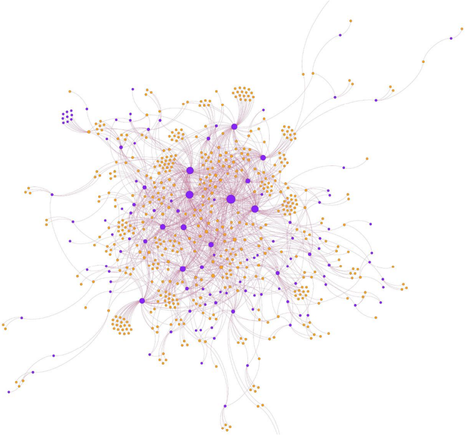


Figure: Loan network for 1987

Purple nodes indicate banks while orange nodes are loans.

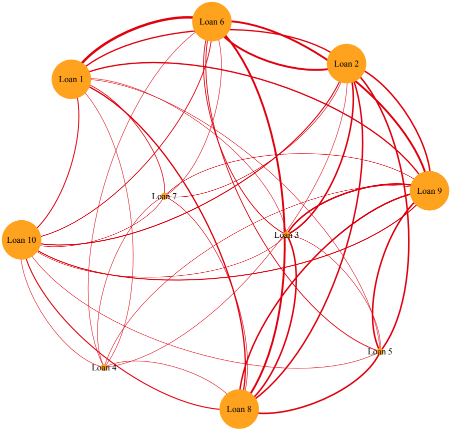


Figure: 10 loan network from 1987

Thicker lines indicate stronger interconnection, larger orange nodes indicate greater number of connections.

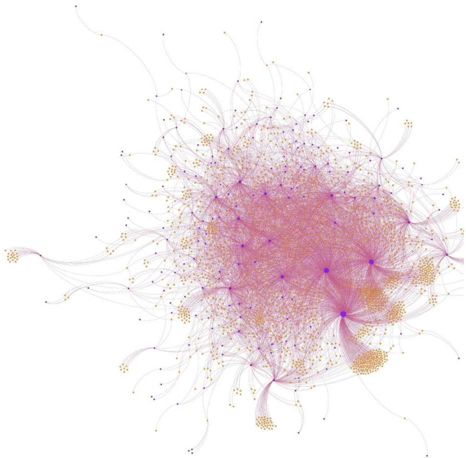


Figure: Loan network for 2006

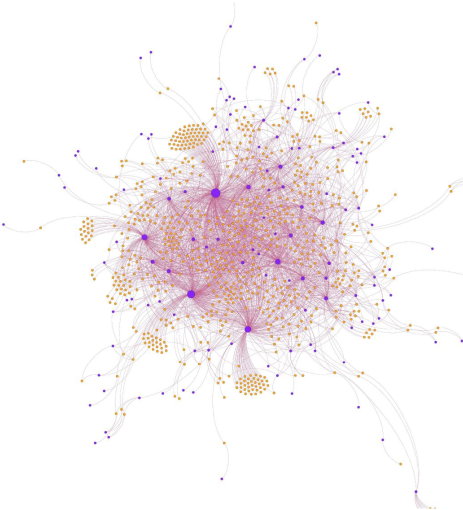


Figure: Loan network for 2009

Syndicated loan network spillovers

$$y_{i,t} = a_b + a_f^{'} + a_l^{''} + a_t^{'''} + \lambda \left(\sum_{j=1, j \neq i}^{L_t} w_{ij,t}^{L} y_{j,t} \right) + \beta_1 B_{i,t-1} + \beta_2 F_{i,t-1} +$$
$$+ \beta_3 L_{i,t} + \epsilon_{i,t}, \; i = 1, \ldots, L_t$$

Where:

- $H_0 : \lambda = 0 \rightarrow$ No spillovers (only fundamentals matter)
- $y_{i,t}$ represents lending rates or quantities for loan i at time t
- $w_{ij,t}^{L}$ is the financial-loan network for loan i and j at time t
- λ is the spatial coefficient (spillover)
- B, F and L are the vectors of bank, firm and loan characteristics used as control variables
- We use firm, bank, loan-type, loan-purpose, and year fixed effects

Baseline results: AISD

	I	II	III	IV	V
Financial-loan network($\hat{\lambda}$)	0.085***	0.087***	-0.050***	-0.047***	0.062***
Bank-control variables	Y	Y	Y	Y	Y
Firm-control variables	Y	Y	Y	Y	Y
Loan-control variables	Y	Y	Y	Y	Y
Observations	52,810	52,810	52,810	52,810	52,810
Moran's $\mathscr{I}$	163.76	147.43	-2.53	-1.46	78.21
$-$Log likelihood	6.217	6.187	6.149	5.951	5.970
Loan-type FE	Y	Y	Y	Y	Y
Loan-purpose FE	Y	Y	Y	Y	Y
Bank FE	N	Y	Y	Y	Y
Year FE	N	N	Y	Y	N
Firm FE	N	N	N	Y	Y
Year FE (exc. crisis FE)	N	N	N	N	Y

The estimate of the *financial-loan network* ($\hat{\lambda}$) is statistically significant at 1%.

Column II: one std. Dev. increase in the interconnectedness between loans $\left(\sigma\left(\sum_{j=1,j\neq i}^{L_t} w_{ij,t}^{L} y_{j,t}\right) = 84.12bps\right)$) increases the *AISD* by approximately 7.32 basis points. Economically this is a large effect, equal to an increase in *AISD* by approximately 4% (calculated from $(7.32/187.11) \times 100$).

Column IV: a one std. dev. increase in $\hat{\lambda}$ yields a decrease in loan spreads by approximately 3.95 basis points.Economically this is a large effect, equal to a 2.1% decrease for the average loan in our sample.

Baseline results: Deal amount ($M)

	I	II	III	IV	V
Financial-loan network ($\hat{\lambda}$)	0.278***	0.270***	0.039**	0.006	0.083***
Bank-control variables	Y	Y	Y	Y	Y
Firm-control variables	Y	Y	Y	Y	Y
Loan-control variables	Y	Y	Y	Y	Y
Observations	52,810	52,810	52,810	52,810	52,810
Moran's $\mathscr{I}$	16.02	14.76	−4.13	−1.56	4.46
−Log likelihood	8.625	8.615	8.606	8.481	8.482
Loan-type FE	Y	Y	Y	Y	Y
Loan-purpose FE	Y	Y	Y	Y	Y
Bank FE	N	Y	Y	Y	Y
Year FE	N	N	Y	Y	N
Firm FE	N	N	N	Y	Y
Year FE (exc. crisis FE)	N	N	N	N	Y

Column II: The estimate of the *financial-loan network* indicates that one std. dev. ($\sigma\left(\sum_{j=1,j\neq i}^{L_t} w_{ij,t}^{L} y_{j,t}\right) = 479.18(\$M)$) increase in the interconnectedness between loans (based on the specifications in column II) increases the *Deal amount* by approximately 129.37 $M (calculated from the product 0.270×479.18). Economically this is a large effect equal to a 27% increase for the average loan in our sample.

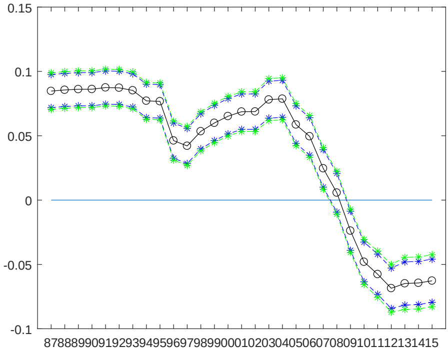


Figure: AISD: year-by-year

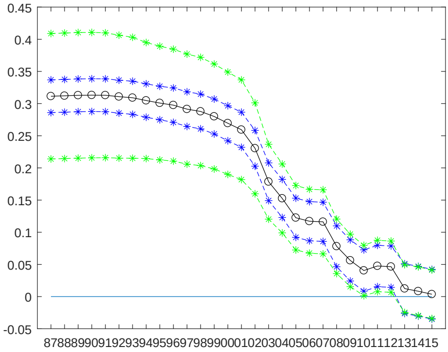


Figure: Deal amount: year-by-year

Interpretation: lending rates

- **Positive** co-movements (good times):
    1. *Strategic interactions (rates as complements)*: Acemoglu et al. (2015a), Acemoglu et al.(2015b) and Calvo-Armengol et al. (2009)
    2. *Behavioural interactions (herding)*: Banks choose to correlate their risk exposure by investing in the same assets (Acharya and Yorulmazer, 2007; Farhi and Tirole, 2012))

- **Negative** co-movements (bad times):
    1. *Strategic interactions (rates as substitutes)*: Acemoglu et al. (2015a) and Goyenko and Ukhov (2009)
    2. *Behavioural interactions (differentiation)*: Bramoulle and Kranton (2007)

Robustness

- Financial complexity and uncertainty Slide
- Network Vs non-network economies Slide
- Bank*Year FE Table page
- AISU Table page
- Spread Table page
- LOC fee Table page
- LOC amount ($M) Table page

Thank you

Testing for complexity and uncertainty

- In our model, unobserved spatial heterogeneity between loans can be interpreted as a measure of network complexity.
- We can explicitly test for the presence of network spillovers in the error term.
- Moran's $\mathscr{I}$ statistic $= \frac{\hat{\epsilon}' W \hat{\epsilon}}{n^{-1}\hat{\sigma}^2 \sqrt{2trace(W^2)}}$.
- $\mathscr{I}$ is a test for $H_0^{\epsilon} : \rho = 0$ in $\epsilon = \rho W \epsilon + \eta$, where η is a disturbance.
- We find that the loan network collapses during the financial crisis due to network complexity and/or counterparty uncertainty.

A counter-factual evaluation of spillovers

- Economy $\mathcal{E}_0$: No W and interest rates $y^0 = \zeta$.
- Economies $\mathcal{E}_1$, $\mathcal{E}_2$ and $\mathcal{E}_3$: W determines interest rates

$$
\begin{aligned}
y^1 &= \lambda_1 W y^1 + \zeta = \lambda_1 W y^1 + y^0, \\
y^2 &= \lambda_2 W y^2 + \zeta = \lambda_2 W y^2 + y^0, \\
y^3 &= \lambda_3 W y^3 + \zeta = \lambda_3 W y^3 + y^0,
\end{aligned}
$$

- Can rewrite above as: $y^i = y^0 + \left(\sum_{\ell=1}^{\infty} \lambda_i^{\ell} W^{\ell}\right) y^0, i = 1, 2, 3.$
- Choose $\lambda_1 = 0.087$, $\lambda_2 = 0.062$ and $\lambda_3 = -0.05$
- We find $a_{\mathcal{E}_1}^{\mathcal{E}_0} = 5.54\%$, $a_{\mathcal{E}_2}^{\mathcal{E}_0} = 3.86\%$, $a_{\mathcal{E}_3}^{\mathcal{E}_0} = -2.81\%$.

Table: Sensitivity tests

	AISU	AISU	Spread	Spread	LOC fee	LOC fee	LOC	LOC	AISD	Deal amount ($M)
	I	II	III	IV	V	VI	VII	VIII	IX	X
Financial-loan network	-0.011 [-0.697]	0.0880*** [5.383]	-0.0604*** [-5.117]	0.0617*** [-5.375]	-0.017 [-0.590]	0.1805*** [-6.339]	0.137*** [3.869]	0.176*** [4.781]	-0.052*** [-4.275]	0.030 [1.223]
Observations	52,810	52,810	52,810	52,810	52,810	52,810	52,810	52,810	52,810	52,810
Bank-control variables	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Firm-control variables	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Loan-control variables	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Loan-type FE	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Loan-purpose FE	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Bank FE	Y	Y	Y	Y	Y	Y	Y	Y	N	N
Year FE	Y	N	Y	N	Y	N	Y	N	N	N
Firm FE	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Year FE (exc. crisis FE)	N	Y	N	Y	N	Y	N	Y	N	N
Bank*Year FE	N	N	N	N	N	N	N	N	Y	Y

The table reports coefficients and t-statistics (in brackets). The dependent is reported in the second line of the table. All specifications include the control variables that are reported in baseline results. Each observation in the regressions corresponds to a different loan. All regressions are estimated with QMLE for SAR models and also include fixed effects as noted in the lower part of the table to control for different levels of unobserved heterogeneity. Standard errors are heteroskedasticity robust. The *,**,*** marks denote the statistical significance at the 10, 5, and % level, respectively.

Robustness slide