A network approach to financial stability

Asena Temizsoy, Giulia Iori and Gabriel Montes-Rojas

Department of Economics
City University London

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Motivation

- The global financial crisis of 2008 has stressed the importance of market interconnectedness on financial stability and highlighted the need to analyse financial markets as a system of individually complex institutions that are connected to one another in a complex network of counterparty exposures.
- One objective of the post-crisis reform agenda has been to identify Systemically Important Financial Institutions (SIFIs). Size, connectedness and substitutability have been identified as the three main criterias that should guide national authorities in their assessment of the systemic importance of financial institutions.
- Regulators have been concerned with eliminating the perception that some financial institutions are too big to fail. Banks perceived as more likely to receive taxpayer support have been shown to benefit from lower funding costs. Implicit subsidy this can create moral hazard and provide incentives to take on additional risk, exacerbating system fragility.

Aim of the paper:

- Establish if the "too-connected to fail" perception of an institution also leads to better funding rates (implicit subsidies). Monitoring how funding cost advantages evolve over time may provide a way to measure the effectiveness on regulatory policy to reduce systemic risk on one side and act as an early warning indicator of systemic risk on the other.
- Establish if stable relationships are formed in the interbank market and assess their impact in terms of financial stability.

Empirical Analysis of e-MID daily transaction data with over-night (O/N) maturity.

We represent the market as a network consisting of nodes (banks) and a time-varying number of, weighted and directed, links between them (representing interbank loans). The direction of the links follow the flow of money (from lenders to borrowers) and the weights are given by the number of loans exchanged by each pair, over a given period of time. Two banks can be connected by two links, one in each direction, if they both act as lenders and borrowers.

We use a panel data regression framework, with time and pair fixed-effects, to study:

- Effect of local and global network centrality, of lender and borrower, on interest rates exchanged by bank pairs.
- Effect to trading concentration on interest rates exchanged by bank pairs.
- We monitor how these effects evolve in time over the Global Financial Crisis period: Phase I, II and III of financial crisis.

Effect of the subprime crisis on interbank lending: cross-section dispersion of credit spreads (e-MID)

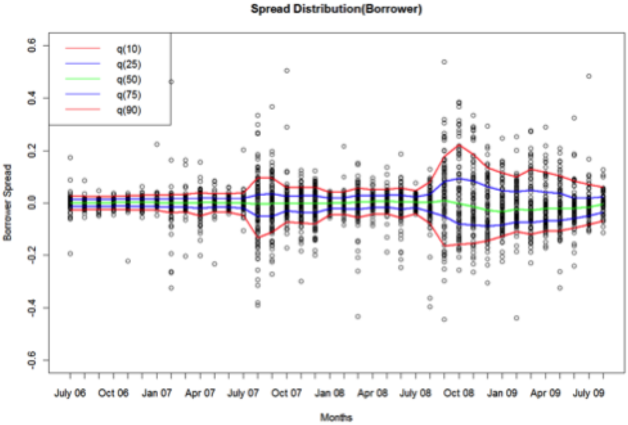


Figure: Montly evolution of the quantiles of estimated cross-sectional distributions of borrower spreads (computed daily and volume-wighted averaged over a quarter)

e-MID: electronic Market for Interbank Deposits

- This market is unique in the Euro area in being a screen based fully electronic interbank market.
- The names of quoting banks are visible next to their quotes (price and volume).
- Both italian banks and foreign banks can exchange funds. Market players are 246 members from 29 EU countries and the US, of which: 108 domestic banks and 106 international banks (mostly EU and US).
- Average exposure of about 5.5 million euros per transaction.
- The e-MID accounted, before the crisis, for 17% of total turnover in unsecured money market in the Euro Area.
- The data base is composed by the records of all transactions registered in the period 01/1999–12/2009 for a total of 1.523.510 transactions.
- For each contract we have information about the date and time of the trade, the quantity, the interest rate and the encoded name of the quoting and ordering bank.
- The banks are reported together with a code representing their country and, when the bank is Italian, a label that indicates the class of capitalization (major, large, medium, small, minor)
- Banks are HIGHLY HETEROGENEOUS in terms of size, numbers of trades and volume exchanged.

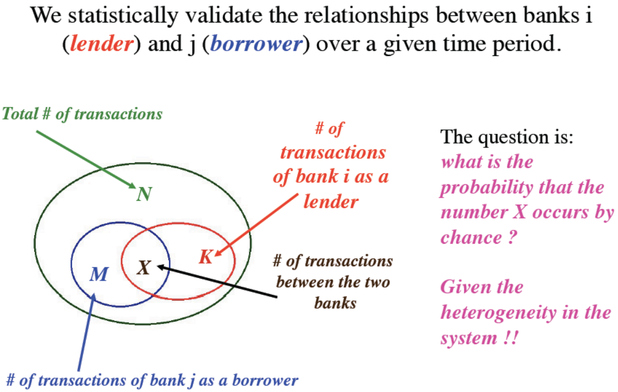
Why the e-MID market?

- Traders in OTC markets actively search for counterparties. When counterparties meet, they negotiate terms privately, often ignoring prices available from other potential counterparties and with limited knowledge about trades recently negotiated elsewhere in the market.
- in OTC markets better connected banks may be able to exploit their market power or benefit from better rates in compensation of their intermediation role. These effects cannot be easily disentangled from potential implicit benefits associated with the "too connected to fail" perception.
- The e-MID is a fully transparent trading platform. There is little scope for intermediation in this market. Search frictions and lack of information on rates offered by alternative lenders cannot be responsible for the observed cross sectional dispersion of O/N rates in this market.
- In a perfectly transparent market there is little scope for relationship lending, unless private information, acquired through repeated transactions, is valuable in mitigating asymmetric information about a counterpart creditworthiness. Our objective is thus to disentangle search frictions from information effects.

Characterization of trading network

- What drives the matching process in the network?
- How dense/sparse is the network?
- What are the more appropriate measures of centrality?

Randomness in matching or stable relationships?[1]

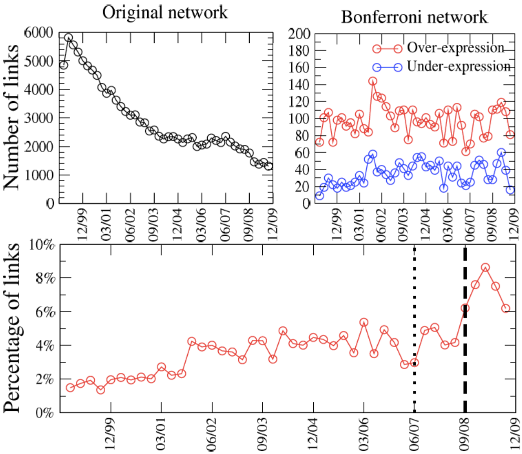


- Over expressed links: occur more often than consistent with a random hypothesis
- Under expressed links: occur less often than consistent with a random hypothesis

[1] V. Hatzopoulos, G. Iori, R. N. Mantegna, S. Miccichè and M. Tumminello, *Quantifying preferential trading in the e-MID interbank market*, Quantitative Finance (2015)

Over expressed and under expressed links

Banks are more likely to be chosen as trading partners because they trade more and not because they are more attractive, even though some stable relationships exist.



While some banks have consistently more links they do not trade with the same counter parties at different times.

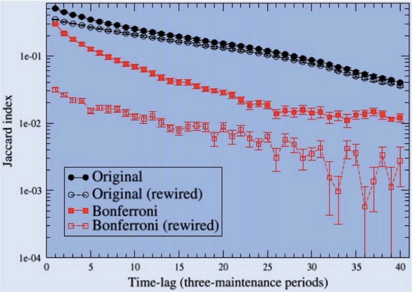


Figure 9. Average-lagged Jaccard index between the network of the 3-maintenance period t with respect to the network of the 3-maintenance period $t + L$, where L is the time-lag ranging from 1 to 40. The data shown in the figure are the average values and standard deviations (error bars) taken over all the 3-maintenance periods, for the lender-aggressor data-set. We show results relative to the original network (black) and the Bonferroni network (red). Open circles and squares refer to randomly rewired networks. The rewiring procedure preserves the node degree. These data refer to the lender-aggressor data-set. The analysis is performed on the Italian segment of the e-MID market.

Basic network metrics

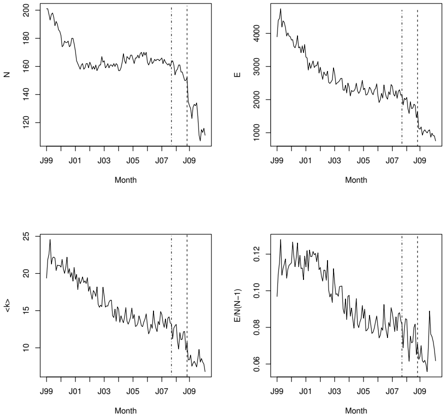


Figure: Number of nodes(top left), number of edges(top right), average degree (bottom left) and edge density(bottom right) for the set of networks defined on non-overlapping intervals of $\delta t = 1$ maintenance period.

Example Monthly Networks

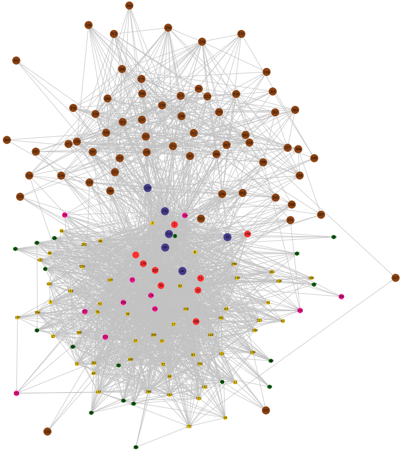
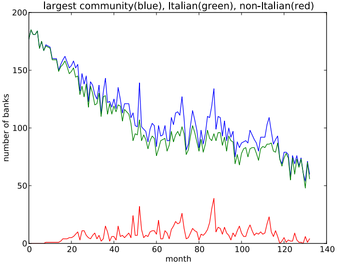


Figure: eMid bank Network in maintenance period 14-Feb-2007 to 13-Mar-2007

Following Martin Rosvall and Carl T. Bergstrom[2]



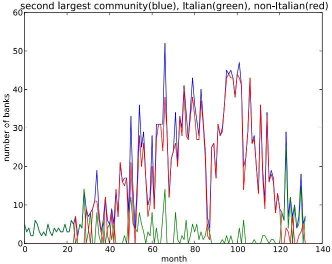


Figure: Composition of the largest two communities in terms of Italian and non-Italian banks.

[2] Maps of random walks on complex networks reveal community structure, PNAS (2008) vol. 105, no. 4, 1118-1123

Data

- The original dataset consists of tick data from e-MID between 15 June 2006 and 7 December 2009, separated into three main periods based on the latest financial turmoil:

Period	Explanation	Number of Maintenance Periods
01 Jan 2006 - 30 Jun 2007	Phase I*	6
01 July 2007 - 30 Sep 2008	Phase II**	5
01 Oct 2008 - 31 Dec 2009	Phase III	5

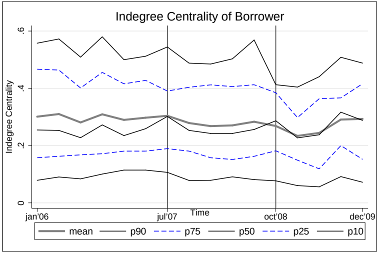
* Bankruptcy of Two Bear Stearns Hedge Fund(31-jul-07)
**Lehman Brothers' collapse (15-sep-08)

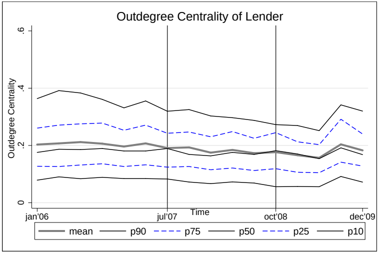
- The dataset is analyzed in two groups; All O/N loans and O/N loans between only local banks(Italian-Italian)

Quantile Analysis of Local Network Measures: Degree

- *Indegree**: Number of counterparties from which a bank borrows loan: $g_i^{in} = \frac{\sum_j g_{ji}}{n-1}$
- *Outdegree**: Number of counterparties to which a bank lends loan: $g_i^{out} = \frac{\sum_j g_{ij}}{n-1}$
- Both variables show a wider distribution of rates before Lehmans' collapse than after, with a decrease in the upper quantile of both measures starting in the second phase.

*All degree centrality measures are normalized by dividing by the maximum possible degree in the network (i.e n-1) at given time period.



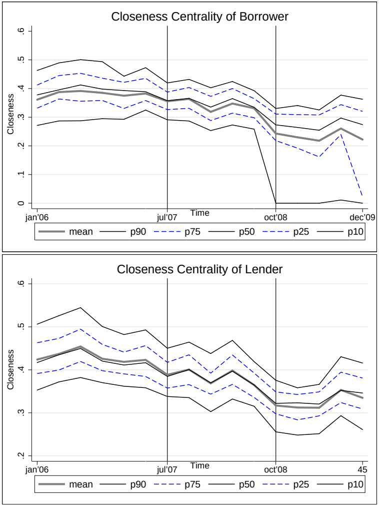


Quantile Analysis of Global Network Measures: Closeness (directed&unweighted)

- *Closeness** is the inverse of the average shortest distance of a bank from all banks that are reachable from it.

$$Closeness(u) = \frac{n-1}{\sum_{v=1}^{n} d(u,v)}$$

- The higher the value the lower the distance separating the bank from the counterparties. A bank with higher closeness centrality is directly connected to more banks in the network.
- Graphs show that closeness decreases during the second and third phase of the 2007-2008 financial turmoil, a trend that is similar to local network measures.



Quantile Analysis of Global Network Measures: Betweenness (directed&unweighted)

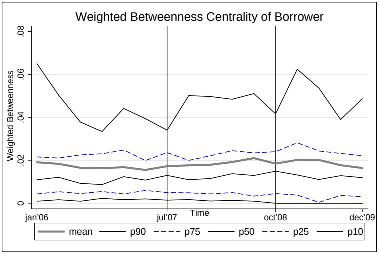
- *Betweenness* is the number of the shortest path between two banks (u and v) that passes through the bank k.

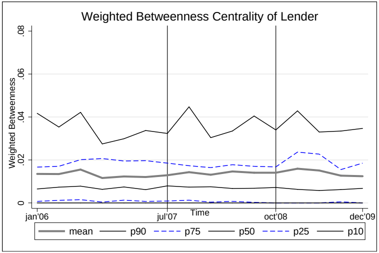
$$Betweenness(k) = \frac{\sum_{u,v} \frac{\sigma(u,v|k)}{\sigma(u,v)}}{(n-1)(n-2)}$$

  where $\sigma(u,v)$ is number of the shortest paths, and $\sigma(u,v|t)$ is the number of paths passing through the bank k other than u, v and n is the number of nodes in the network.

- Betweenness measures a bank's access to the interbank liquidity. A bank with higher betweenness can be perceived as part of a larger loan chain and has a structurally more important position in the network.

- There is no clear change in the weighted and directed betweenness centrality of banks over time.





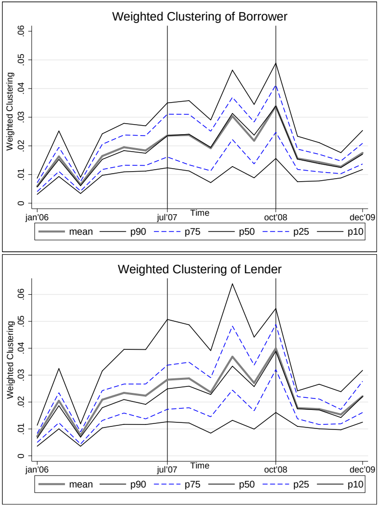
Quantile Analysis of Global Network Measures: Clustering (undirected&weighted)

- *Clustering* is the probability of two neighbours of a node having a common edge.

$$wClustering(u) = \frac{\sum_{uvk} (\hat{w}_{uv}\hat{w}_{uk}\hat{w}_{vk})^{1/3}}{deg(u)(deg(u)-1)}$$

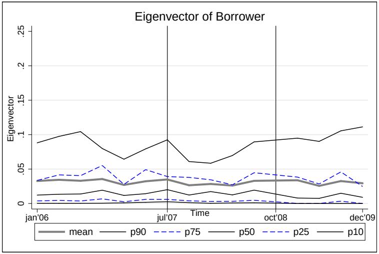
where $\hat{w}_{uv} = \frac{w_{uv}}{max(w)}$

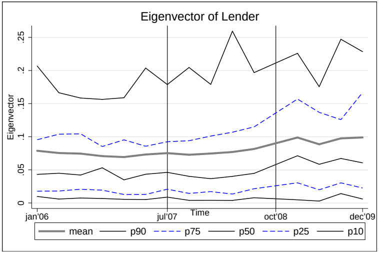
- The centrality measure indicates how concentrated the neighborhood of a bank is and indicates the higher counterparty risk with a greater value of measure.
- Distributions of weighted clustering are less dispersed during the last phase of the crisis..



Quantile Analysis of Global Network Measures: Eigenvector

- *Eigenvector Centrality* is defined as the principal eigenvector of the adjacency matrix defining the connected network and it is calculated as $\lambda v = gv$, where g is the adjacency matrix of the graph, λ is the eigenvalue which is a constant and v is eigenvector. The eigenvector centrality of a node can be interpreted as the fraction of time that a random walk(er) will spend at that node over an infinite time horizon.
- A bank has a higher value of the eigenvector measure when its neighbors are also connected to the network.
- There is not any clear change in the quantiles of eigenvector over time, that is, global concentration does not change during 2007-2008 financial turmoil. Lenders are more central than borrowers over all phase.



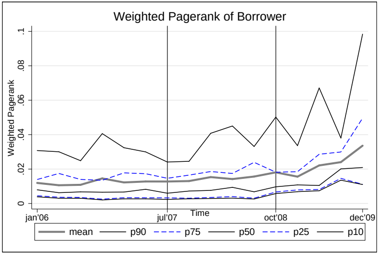


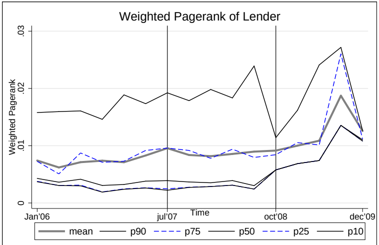
Quantile Analysis of Global Network Measures: Pagerank (directed&weighted)

- *Pagerank Centrality* PageRank is an eigenvector based algorithm. The score for a given node may be thought of as the fraction of time spent visiting that node in a random walk over the vertices. PageRank modifies this random walk by adding to the model a probability of jumping to any other vertex. The transition probabilities across outgoing arcs differ depending on the weights of the arcs.

$$PR(u) = \frac{1-d}{N} + d \sum_{v} \frac{PR(v)}{L(v)}$$

- Where $L(v)$ are outgoing links of nodes v (that point to u). We take damping factor as $d = 85\%$.
- Graphs presents an increase in the quantiles of pagerank for both lenders and borrowers





Methodology

- Interbank rate spread is calculated as

$$S_{ij,q} = \frac{1}{\sum_{t=1}^{T_{ij,q}} V_{ij,t}} \sum_{t=1}^{T_{ij,q}} (r_{ij,t} - \bar{r}_q) * V_{ij,t}$$

where $r_{ij,t}$ is transaction level interest rate outstanding for each pair of banks ij where $i \neq j$ at time t, and $\bar{r}_q$ the quarterly volume weighted average rate over all transactions carried out by the bank pairs.

- Spread calculation is based on e-MID volume weighted average rate as opposed to EONIA or ECB rates.
- We consider the following empirical model in order to examine the network centrality measures on bank spreads:

$$S_{ij,t} = \beta_0 + \beta_1 A_{ij,t} + \beta_2 B_{ij,t} + \beta_3 C_{ij,t} + \beta_4 D_{i,t} + \beta_5 E_{j,t} + u_{ij,t}$$
$$u_{ij,t} = \mu_{ij} + \delta_t + e_{ij,t}$$

where t indexes time, $A_{ij,t}$ and $B_{ij,t}$ are vectors of bank centrality measures including indegree, outdegree, closeness, betweenness centrality and eigenvector of lender and borrower respectively. C, D and E represent pair, lender and borrower related variables respectively, and $u_{ij,t}$ is the residual.

- We apply all our models to the panel data with bank pair and time fixed effects represented as μ_{ij} and δ_t respectively. The former captures bank unobserved characteristics, such as creditworthiness and size. The latter captures the evolution of the market across time and common shocks that affect all banks.
- We run the regression for each centrality measure separately.

Table: All O/N Loans -Effect of Local Network Measures on Interbank Rate Spread

VARIABLES	(1) All	(2) Phase I	(3) Phase II	(4) Phase III	(5) All	(6) Phase I	(7) Phase II	(8) Phase III
Transaction Ratio	4.977***	-1.162	1.440	4.606***	4.989***	-1.381	0.367	4.636***
	(1.735)	(1.157)	(1.696)	(1.621)	(1.738)	(1.146)	(1.680)	(1.631)
AM/PM Ratio	2.313***	1.149***	3.198***	1.615***	2.314***	1.147***	3.173***	1.627***
	(0.082)	(0.090)	(0.169)	(0.200)	(0.082)	(0.090)	(0.169)	(0.200)
Quot/Agg Ratio	1.508***	0.815***	1.673***	2.773***	1.505***	0.818***	1.687***	2.765***
	(0.103)	(0.120)	(0.213)	(0.274)	(0.103)	(0.120)	(0.213)	(0.273)
Reciprocity Ratio	-0.087***	0.027	-0.056*	-0.119	-0.088***	0.030	-0.048	-0.128
	(0.017)	(0.038)	(0.034)	(0.179)	(0.017)	(0.038)	(0.029)	(0.183)
Outdegree L/link(%)	-0.909***	0.596**	0.248	-1.399***	-0.699***	0.349	-0.116	-1.267***
	(0.194)	(0.274)	(0.528)	(0.425)	(0.203)	(0.303)	(0.582)	(0.427)
Indegree B/link(%)	0.936***	1.226***	0.904**	2.544***	0.809***	1.277***	0.345	2.465***
	(0.140)	(0.221)	(0.367)	(0.269)	(0.148)	(0.254)	(0.383)	(0.302)
Indegree L/link(%)					0.507***	-0.445*	-0.694*	0.314
					(0.164)	(0.262)	(0.420)	(0.285)
Outdegree B/link(%)					-0.388**	0.078	-1.758***	-0.294
					(0.151)	(0.230)	(0.422)	(0.403)
Observations	37,872	16,314	13,811	7,747	37,872	16,314	13,811	7,747
R-squared	0.090	0.035	0.078	0.164	0.090	0.035	0.080	0.165
Number of pair_id	6,674	5,218	4,992	3,109	6,674	5,218	4,992	3,109

Robust standard errors in parentheses. *** $p<0.01$, ** $p<0.05$, * $p<0.1$

Table: All O/N Loans - Effect of Global Network Measures on Spread - I

VARIABLES	(1) All	(2) Phase I	(3) Phase II	(4) Phase III
Transaction Ratio	6.719***	1.932*	2.976*	10.939***
	(2.313)	(1.028)	(1.651)	(1.513)
AM/PM Ratio	2.388***	1.175***	3.231***	1.915***
	(0.085)	(0.091)	(0.172)	(0.202)
Quot/Agg Ratio	1.479***	0.804***	1.653***	2.766***
	(0.103)	(0.119)	(0.213)	(0.279)
Closeness of L	-10.956***	3.234	-0.181	-21.280***
	(1.776)	(2.232)	(4.094)	(4.362)
Closeness of B	-1.742***	-0.856	-5.140***	-5.109***
	(0.611)	(0.642)	(1.586)	(1.660)
Observations	37,872	16,314	13,811	7,747
R-squared	0.087	0.032	0.077	0.144
Number of pair_id	6,674	5,218	4,992	3,109

Robust standard errors in parentheses. *** $p<0.01$, ** $p<0.05$, * $p<0.1$

Table: All O/N Loans -Effect of Global Network Measures on Spread - II

VARIABLES	(1) All	(2) Phase I	(3) Phase II	(4) Phase III	(5) All	(6) Phase I	(7) Phase II	(8) Phase III
Transaction Ratio	5.738***	2.786***	3.368**	9.607***	4.614***	2.843***	3.256**	9.055***
	(1.836)	(0.998)	(1.621)	(1.480)	(1.399)	(1.057)	(1.613)	(1.621)
AM/PM Ratio	2.340***	1.182***	3.200***	1.935***	2.316***	1.183***	3.238***	1.999***
	(0.084)	(0.092)	(0.173)	(0.202)	(0.083)	(0.092)	(0.175)	(0.203)
Quot/Agg Ratio	1.476***	0.797***	1.626***	2.757***	1.425***	0.797***	1.644***	2.643***
	(0.102)	(0.119)	(0.212)	(0.281)	(0.104)	(0.119)	(0.216)	(0.282)
Betweenness of L(w)	-3.997	-13.903	1.659	-15.317**				
	(4.849)	(8.571)	(10.246)	(7.192)				
Betweenness of B(w)	-20.555***	-8.722	-54.954***	-2.909				
	(4.199)	(5.431)	(11.183)	(6.454)				
Clustering of L(w)					-8.630	-3.498	6.901	-105.754***
					(7.072)	(7.132)	(13.516)	(22.001)
Clustering of B(w)					96.817***	15.188	24.071	149.629***
					(13.155)	(11.590)	(21.363)	(22.707)
Observations	37,872	16,314	13,811	7,747	37,872	16,314	13,811	7,747
R-squared	0.085	0.032	0.081	0.135	0.089	0.032	0.076	0.154
Number of pair_id	6,674	5,218	4,992	3,109	6,674	5,218	4,992	3,109

Robust standard errors in parentheses. *** $p<0.01$, ** $p<0.05$, * $p<0.1$

Table: All /ON Loans -Effect of Global Network Measures on Spread - III

VARIABLES	(1) All	(2) Phase I	(3) Phase II	(4) Phase III	(5) All	(6) Phase I	(7) Phase II	(8) Phase III
Transaction Ratio	6.592***	2.261	3.118	20.032***	8.240***	1.864*	2.115	13.164***
	(2.186)	(1.608)	(2.399)	(7.726)	(1.199)	(1.118)	(1.530)	(1.565)
AM/PM Ratio	2.106***	0.970***	3.100***	0.999	2.145***	1.174***	3.205***	1.329***
	(0.126)	(0.132)	(0.230)	(0.684)	(0.075)	(0.091)	(0.171)	(0.165)
Quot/Agg Ratio	1.391***	0.683***	1.686***	1.509**	1.394***	0.798***	1.702***	2.282***
	(0.174)	(0.163)	(0.353)	(0.758)	(0.097)	(0.119)	(0.215)	(0.235)
Pagerank of L	-3.308	-25.872**	14.723*	17.735				
	(7.164)	(10.169)	(8.404)	(53.697)				
Pagerank of B	15.818***	7.392*	26.373***	24.814				
	(4.447)	(4.099)	(7.599)	(21.258)				
Eigenvector of L					-4.080***	0.409	-0.821	-11.250***
					(0.696)	(0.835)	(1.398)	(1.522)
Eigenvector of B					-12.471***	-4.437**	-24.094***	-18.059***
					(1.521)	(1.965)	(4.766)	(3.461)
Observations	15,685	8,379	6,005	1,301	36,062	16,314	13,811	5,937
R-squared	0.065	0.025	0.083	0.109	0.076	0.032	0.082	0.126
Number of pair_id	3,915	3,048	2,591	808	6,613	5,218	4,992	2,664

Robust standard errors in parentheses. *** $p<0.01$, ** $p<0.05$, * $p<0.1$

Conclusion I: centrality matters.

- The empirical results show that interbank spreads are significantly affected by the banks position in the network, measured by both local and global connectedness measures.
- Lenders pay a premium (i.e. obtain lower rates) for being more central, at both local and global measures.
- This effect is statistically significant for post-Lehman's Brothers collapse sub-period.
- Borrowers, on the other hand, pay a higher premium (i.e. higher rates) for better local connections, but significantly benefit for better global centrality.
- The effect of network measures on interest rate spread changes over time: some change the sign, some have larger effect during and/or after crisis in comparison to the period before crisis.
- The results from only Italian banks are similar to the results of the analysis where both Italian and foreign banks are taken into account. Overall this suggest that foreign banks do not distort the network effects.

A look at relationship lending (with Montes-Rojas and Temizsoy)

- Dependent variable is pair volume weighted spread over average daily market rate calculated as

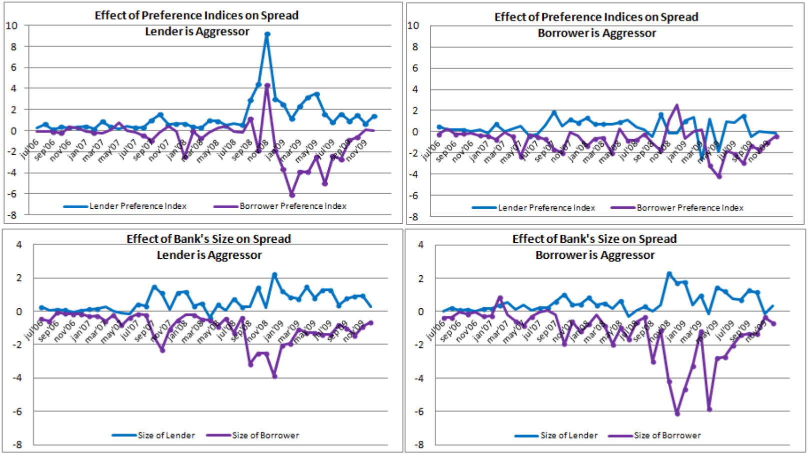
$$S_{ij,t} = \frac{1}{\sum_{t=1}^{N_{ij,t}} V_{ij,n}} \sum_{t=1}^{N_{ij,m}} (r_{ij,n} - \bar{r}^{d}_{m,}) * V_{ij,n}$$

where $r_{ij,n}$ is a transaction level interest rate outstanding for each pair of banks ij where $i \neq j$ at time t, and $\bar{r}^{d}_{m}$ the daily volume weighted average rate over all transactions carried out by the bank pairs.

- And transaction concentration are calculated as

$$LPI^{w}_{ij,t} = \frac{\sum_{t=1}^{T} y_t^{i \to j}}{\frac{\sum_{t=1}^{T} y_t^{i \to any}}{outdegree_i}}, \; BPI^{w}_{ij,t} = \frac{\sum_{t=1}^{T} y_t^{i \to j}}{\frac{\sum_{t=1}^{T} y_t^{any \to j}}{indegree_i}},$$

- We run the same regression with four month average value of preference indexes in order to analyse if the effect of short and long term relationship differ.
- In order to have enhanced precision for the effect of preference index, only the pairs where both lender and borrower have more than one transaction are included in the empirical study.
- We also restrict our analysis to banks that actively participate in the interbank overnight market for all periods before, during and after the financial crisis of 2008


Effect of Preference Indices on Spread
Lender is Aggressor
Lender Preference Index
Borrower Preference Index
Effect of Preference Indices on Spread
Borrower is Aggressor
Lender Preference Index
Borrower Preference Index
Effect of Bank's Size on Spread
Lender is Aggressor
Size of Lender
Size of Borrower
Effect of Bank's Size on Spread
Borrower is Aggressor
Size of Lender
Size of Borrower

LENDER is AGGRESSOR - Weighted Spread over Weighted Average Market Rate

VARIABLES	(1) All	(2) Before Crisis	(3) During Crisis	(4) After Crisis	(5) All	(6) Before Crisis	(7) During Crisis	(8) After Crisis
Transaction Ratio	0.636***	0.763***	0.331	0.441***	0.462***	0.342***	0.576***	0.246***
	(0.155)	(0.184)	(0.246)	(0.167)	(0.086)	(0.084)	(0.126)	(0.084)
AM/PM Ratio	2.409***	1.242***	3.445***	1.802***	2.397***	1.244***	3.431***	1.790***
	(0.063)	(0.082)	(0.123)	(0.108)	(0.063)	(0.081)	(0.123)	(0.108)
Reciprocity Ratio	-0.453***	-0.089	-0.838**	0.008	-0.448***	-0.083	-0.842**	0.013
	(0.128)	(0.199)	(0.336)	(0.142)	(0.127)	(0.199)	(0.337)	(0.142)
LPI^w	0.684***	-0.032	0.566***	0.857***				
	(0.091)	(0.093)	(0.160)	(0.170)				
BPI^w	-0.677***	-0.240**	-0.177	-1.027***				
	(0.105)	(0.095)	(0.165)	(0.182)				
LPI^w(4M)					0.957***	0.077	0.402**	1.275***
					(0.110)	(0.128)	(0.203)	(0.200)
BPI^w(4M)					-0.573***	0.003	-0.144	-0.910***
					(0.113)	(0.117)	(0.219)	(0.220)
Lender's B/L Ratio	-0.006**	-0.005	-0.007	-0.001**	-0.006**	-0.005	-0.007	-0.001**
	(0.003)	(0.004)	(0.007)	(0.000)	(0.003)	(0.004)	(0.007)	(0.000)
Borrower's L/B Ratio	-0.024***	-0.016	-0.019	-0.071***	-0.024***	-0.016	-0.019	-0.071***
	(0.008)	(0.010)	(0.016)	(0.018)	(0.008)	(0.010)	(0.016)	(0.018)
Observations	51,860	19,274	20,726	11,860	51,860	19,274	20,726	11,860
R-squared	0.086	0.036	0.085	0.124	0.086	0.036	0.084	0.122
Number of pair_id	6,063	4,448	4,438	2,727	6,063	4,448	4,438	2,727

Robust standard errors in parentheses
*** $p<0.01$, ** $p<0.05$, * $p<0.1$
Spread is expressed in basis points. All models include bank pair and maintenance period specific fixed effects.

- We apply logistic distribution function to the panel data with bank pair and time fixed effects in order to explore the hypothesis that having stronger relationship with a counterparty increase the probability of having transaction with the same counterparty in the next month. The dependent variable survival represented by a binary choice variable $survival_{ij,t} = 1$ if the trades happens or 0 if the pair is not active for all pairs ij at time t.

$$Pr(Survival_{ij,t+1} = 1 | X_{it} = F(X_{ijt}\beta + u_{ij,t})$$
$$u_{ij,t} = \mu_{ij} + \delta_t + e_{ij,t},$$

where $Pr(.)$ is the conditional probability of pairs being active in the next month, X_{ijt} is set of the relevant variables ($S_{ij,t}$, $LPI_{ij,t}$ and $BPI_{ij,t}$), $F(.)$ is logit cumulative probability function t indexes time and $u_{ij,t}$ is the residual.

Lender is Aggressor - Marginal Effect of Survival Analysis for the next period				
	(1)	(2)	(3)	(4)
VARIABLES	All	Before Crisis	During Crisis	After Crisis
Spread	0.001***	-0.001	-0.000	-0.001
	(0.000)	(0.001)	(0.000)	(0.001)
LPI^W	0.087***	0.037***	0.045***	0.071***
	(0.005)	(0.012)	(0.010)	(0.012)
BPI^W	0.071***	0.075***	0.097***	0.045***
	(0.005)	(0.011)	(0.010)	(0.012)
Observations	47,690	14,577	16,280	10,175
Number of pair_id	3,866	2,330	2,459	1,563

Marginal Effect of Survival Analysis for the next two consecutive periods				
	(1)	(2)	(3)	(4)
VARIABLES	All	Before Crisis	During Crisis	After Crisis
Spread	0.001***	-0.002*	-0.000	-0.004***
	(0.000)	(0.001)	(0.001)	(0.001)
LPI^W	0.080***	0.027**	0.032***	0.064***
	(0.005)	(0.012)	(0.010)	(0.011)
BPI^W	0.055***	0.054***	0.068***	0.022*
	(0.005)	(0.011)	(0.010)	(0.011)
Observations	42,292	11,792	13,777	8,490
Number of pair_id	2,780	1,553	1,709	1,058

We apply logit to the panel data with bank pair and time fixed effects.
$Survival_{ij,t} = 1$ if the trades happens or 0 if the pair is not active for all pairs ij at time t

Conclusion II: relationships matters.

We show that

- Trading with preferred counterparts leads to more favourable rates and carries larger volumes.
- Our interpretation is that lenders are willing to provide a discount to borrowers for taking funding risk, in return for better monitoring opportunity, while borrower are willing to pay a premium to lender for taking non diversification risk, in return for preferential access to liquidity.
- The results point to a peer monitoring role of relationship lending in the e-MID market
- Private information acquired through frequent transactions, by improving the ability of banks to assess the creditworthiness of their counter parties, supported liquidity reallocation in the e-MID market during the crisis.

- Relationship lending thus played a positive role for financial stability and the default, or exit from the market, of banks that are important relationship lenders or borrowers may lead to a deterioration of the interbank credit market.
- The policy implication is that when establishing if a bank is too connected to fail, regulators should not only look at how connected a bank is, but also at how preferentially connected it is to other key players.

THANK YOU!