B Supplementary Information – Not for Publication

B.1 Comparison of Direct and Indirect Access to Liquidity

While we are interested in studying the effect of a bank's network centrality on its access to liquidity, it is instructive to compare the effect of an increase in a global measure, such as network centrality, with the effect of an increase in local network measures, such as a bank's weighted and unweighted in-degree. All network variables are computed in an initial reference period to avoid issues of reverse causality.

Tables (14) - (17) show the estimates for model 20. Banks that have 10% more lenders in the initial period borrow on average 3.9% more subsequently and, similarly, banks that borrow a 10% larger amount in the initial period borrow on average 2.8% more subsequently. The relation is less pronounced for network centralities, which is to be expected as these capture also non-local effects which can work opposite to the positive local effects.

As a robustness check, we also study access to liquidity measured as the number of counterparties a bank borrows from on a given day. We use model 20 and show the results of this estimation in Tables (18) - (21). A better network position in the initial period also translates into access to more lenders in the subsequent periods. On aggregate the number of lenders does not change significantly, except in the full-allotment period when it is slightly smaller than in the initial period. Not surprising, the relative size of a bank, i.e. how much it borrows on the interbank market in the initial period is positively correlated with the number of lenders subsequently. Our main explanatory variables are significant again and we can observe the same pattern as with the other measures of access to liquidity. A 10%

increase in the number of lenders in the initial period leads to a 2.6% increase in the number of lenders subsequently. A 10% increase in the amount borrowed leads to a 1% increase in the number of subsequent borrowers. A 10% increase in betweenness (Katz) centrality in the initial period leads to a 2.6% (1.2%) increase in the number of borrowers subsequently.

Table 14: Amount Borrowed explained by In-Degree.

	(1)	(2)	(3)	(4)
Pre-Lehman	4.144	2.281	17.085	82.695*
	(43.949)	(43.863)	(37.042)	(42.716)
Post-Lehman	47.794	46.028	193.475***	138.676***
	(48.461)	(48.557)	(56.851)	(52.917)
SRO	-64.534	-64.118	-65.149	153.333***
	(65.112)	(65.235)	(65.812)	(53.861)
Full Allotment	-187.973**	-187.423**	-79.924	167.726**
	(73.647)	(73.800)	(62.765)	(68.119)
Relative Size	268.559***	141.206**	216.371**	-125.722*
	(95.026)	(58.392)	(100.112)	(70.645)
Loan Loss Reserves	-0.004	-0.005	-0.063***	-0.075***
	(0.004)	(0.004)	(0.021)	(0.024)
Assets	0.000	0.000	0.001***	0.001***
	(0.000)	(0.000)	(0.000)	(0.000)
Degree		9.535***		11.090***
		(1.732)		(1.676)
(Degree × Date)				
Pre-Lehman				-2.278
				(1.399)
Post-Lehman				1.055
				(1.428)
SRO				-6.855***
				(1.852)
Full Allotment				-8.493***
				(2.303)
Controls × date	No	No	Yes	Yes
N	4348	4348	4348	4348
R^2 (within)	0.021	0.020	0.016	0.043
R^2 (between)	0.000	0.355	0.159	0.549
R^2 (overall)	0.019	0.212	0.219	0.363

Note: The dependent variable is $\text{Amount}_{i,t}$, i.e. the amount a bank i borrows on the interbank market on day t. The explanatory variable is the number of banks bank i borrows from during an initial reference period. We use the following bank-specific controls, all reported at the end of 2007. The relative size is the amount of interbank lending during the initial reference period divided by the total asset size. The Loan Loss Reserves are a proxy for the bank's riskiness and Assets is the total asset size. Date indicates a period dummy that is one in the respective period, and zero otherwise. The dates for the periods are as follows. Init: 04 July - 21 July; Pre-Lehman: 28 August - 12 September; Post-Lehman: 15 September - 29 September; SRO: 30 September - 14 October; Full Allotment: 15 October - 30 October.

Table 15: Amount Borrowed explained by Weighted In-Degree

	(1)	(2)	(3)	(4)
Pre-Lehman	4.144	3.215	17.085	50.328
	(43.949)	(43.837)	(37.042)	(35.425)
Post-Lehman	47.794	47.216	193.475***	164.558***
	(48.461)	(48.538)	(56.851)	(51.169)
SRO	-64.534	-62.792	-65.149	112.429**
	(65.112)	(65.056)	(65.812)	(48.760)
Full Allotment	-187.973**	-185.630**	-79.924	95.413*
	(73.647)	(73.663)	(62.765)	(49.950)
Relative Size	268.559***	84.895*	216.371**	-286.201**
Loan Loss Reserves	-0.004	-0.004	-0.063***	-0.034
	(0.004)	(0.004)	(0.021)	(0.021)
Assets	0.000	0.000	0.001***	0.001***
	(0.000)	(0.000)	(0.000)	(0.000)
Weighted In-Degree		0.065***		0.070***
		(0.015)		(0.016)
(Weighted In-Degree × Date)				
Pre-Lehman				-0.009
				(0.011)
Post-Lehman				0.009
				(0.014)
SRO				-0.045***
				(0.016)
Full Allotment				-0.060***
				(0.016)
Controls × date	No	No	Yes	Yes
N	4348	4348	4348	4348
R^2 (within)	0.021	0.019	0.016	0.038
R^2 (between)	0.000	0.418	0.159	0.569
R^2 (overall)	0.019	0.251	0.219	0.374

Note: The dependent variable is $\text{Amount}_{i,t}$, i.e. the amount a bank i borrows on the interbank market on day t. The explanatory variable is i's total interbank borrowing Weighted In-Degree during an initial reference period. We use the following bank-specific controls, all reported at the end of 2007. The relative size is the amount of interbank lending during the initial reference period divided by the total asset size. The Loan Loss Reserves are a proxy for the bank's riskiness and Assets is the total asset size. Date indicates a period dummy that is one in the respective period, and zero otherwise. The dates for the periods are as follows. Init: 04 July - 21 July; Pre-Lehman: 28 August - 12 September; Post-Lehman: 15 September - 29 September; SRO: 30 September - 14 October; Full Allotment: 15 October - 30 October.

Table 16: Borrowing and Lending Spread explained by In-Degree.

	(1)	(2)	(3)	(4)
Pre-Lehman	0.025***	0.026***	0.024***	0.024***
	(0.005)	(0.005)	(0.006)	(0.008)
Post-Lehman	0.010	0.011	0.015	0.033**
	(0.011)	(0.011)	(0.013)	(0.015)
SRO	-0.041	-0.041	-0.013	-0.001
	(0.026)	(0.026)	(0.031)	(0.036)
Full Allotment	-0.246***	-0.246***	-0.229	-0.197***
	(0.029)	(0.029)	(0.036)	(0.043)
Relative Size	0.007	0.011**	0.011*	0.002
	(0.006)	(0.006)	(0.006)	(0.013)
Loan Loss Reserves	0.000*	0.000***	0.000	0.000
	(0.000)	(0.000)	(0.000)	(0.000)
Assets	0.000	0.000	0.000	0.000
	(0.000)	(0.000)	(0.000)	(0.000)
Degree		-0.001***		0.000
		(0.000)		(0.000)
(Degree × Date)				
Pre-Lehman				0.000
				(0.000)
Post-Lehman				-0.001***
				(0.000)
SRO				0.000
				(0.001)
Full Allotment				-0.001
				(0.001)
Controls × date	No	No	Yes	Yes
N	4348	4348	4348	4348
R^2 (within)	0.160	0.160	0.166	0.170
R^2 (between)	0.172	0.187	0.181	0.192
R^2 (overall)	0.131	0.142	0.140	0.152

Note: The dependent variable is $\text{Spread}_{i,t}$, i.e. the Weighted In-Degree-weighted spread a bank i pays for liquidity on the interbank market on day t. The explanatory variable is the number of banks bank i borrows from during an initial reference period. We use the following bank-specific controls, all reported at the end of 2007. The relative size is the amount of interbank lending during the initial reference period divided by the total asset size. The Loan Loss Reserves are a proxy for the bank's riskiness and Assets is the total asset size. Date indicates a period dummy that is one in the respective period, and zero otherwise. The dates for the periods are as follows. Init: 04 July - 21 July; Pre-Lehman: 28 August - 12 September; Post-Lehman: 15 September - 29 September; SRO: 30 September - 14 October; Full Allotment: 15 October - 30 October.

Table 17: Borrowing and Lending Spread explained by Weighted In-Degree

	(1)	(2)	(3)	(4)
Pre-Lehman	0.025***	0.025***	0.024***	0.026***
	(0.005)	(0.005)	(0.006)	(0.007)
Post-Lehman	0.010	0.011	0.015	0.027*
	(0.011)	(0.011)	(0.013)	(0.014)
SRO	-0.041	-0.041	-0.013	-0.012
	(0.026)	(0.026)	(0.031)	(0.033)
Full Allotment	-0.246***	-0.246***	-0.229	-0.214***
	(0.029)	(0.029)	(0.036)	(0.038)
Relative Size	0.007	0.011*	0.011*	0.002
	(0.006)	(0.006)	(0.006)	(0.014)
Loan Loss Reserves	0.000*	0.000***	0.000	0.000
	(0.000)	(0.000)	(0.000)	(0.000)
Assets	0.000	0.000	0.000	0.000
	(0.000)	(0.000)	(0.000)	(0.000)
Weighted In-Degree		-4.2e-06**		0.000
		(0.000)		(0.000)
(Weighted In-Degree × Date)				
Pre-Lehman				0.000
				(0.000)
Post-Lehman				-3.7e-06**
				(0.000)
SRO				0.000
				(0.000)
Full Allotment				0.000
				(0.000)
Controls × date	No	No	Yes	Yes
N	4348	4348	4348	4348
R^2 (within)	0.160	0.160	0.166	0.168
R^2 (between)	0.172	0.184	0.181	0.190
R^2 (overall)	0.131	0.140	0.140	0.148

Note: The dependent variable is $\text{Spread}_{i,t}$, i.e. the Weighted In-Degree-weighted spread a bank i pays for liquidity on the interbank market on day t. The explanatory variable is i's total interbank borrowing Weighted In-Degree during an initial reference period. We use the following bank-specific controls, all reported at the end of 2007. The relative size is the amount of interbank lending during the initial reference period divided by the total asset size. The Loan Loss Reserves are a proxy for the bank's riskiness and Assets is the total asset size. Date indicates a period dummy that is one in the respective period, and zero otherwise. The dates for the periods are as follows. Init: 04 July - 21 July; Pre-Lehman: 28 August - 12 September; Post-Lehman: 15 September - 29 September; SRO: 30 September - 14 October; Full Allotment: 15 October - 30 October.

Table 18: Number of Loans Obtained and Provided explained by Degree.

	(1)	(2)	(3)	(4)
Pre-Lehman	-0.335	-0.339	-0.350	-0.192
	(0.261)	(0.259)	(0.257)	(0.248)
Post-Lehman	0.328	0.323	0.302	0.337
	(0.268)	(0.267)	(0.310)	(0.317)
SRO	-0.056	-0.061	-0.242	0.718*
	(0.453)	(0.452)	(0.444)	(0.414)
Full Allotment	-0.736*	-0.737*	-0.739	0.654
	(0.440)	(0.440)	(0.513)	(0.438)
Relative Size	1.070***	0.636**	0.909***	-0.131
	(0.342)	(0.274)	(0.341)	(0.291)
Loan Loss Reserves	0.000	0.000	0.000*	0.000*
	(0.000)	(0.000)	(0.000)	(0.000)
Assets	0.000	0.000	0.000*	0.000
	(0.000)	(0.000)	(0.000)	(0.000)
Degree		0.062***		0.079***
		(0.014)		(0.015)
(Degree × Date)				
Pre-Lehman				-0.006
				(0.008)
Post-Lehman				-0.006
				(0.009)
SRO				-0.031***
				(0.009)
Full Allotment				-0.047***
				(0.009)
Controls × date	No	No	Yes	Yes
N	4348	4348	4348	4348
R^2 (within)	0.015	0.015	0.041	0.082
R^2 (between)	0.003	0.397	0.002	0.317
R^2 (overall)	0.001	0.221	0.001	0.197

Note: The dependent variable is $\#\text{Loans}_{i,t}$, i.e. the number of interbank loans a bank i obtains on the interbank market on day t. The explanatory variable is the number of banks bank i borrows from during an initial reference period. We use the following bank-specific controls, all reported at the end of 2007. The relative size is the amount of interbank lending during the initial reference period divided by the total asset size. The Loan Loss Reserves are a proxy for the bank's riskiness and Assets is the total asset size. Date indicates a period dummy that is one in the respective period, and zero otherwise. The dates for the periods are as follows. Init: 04 July - 21 July; Pre-Lehman: 28 August - 12 September; Post-Lehman: 15 September - 29 September; SRO: 30 September - 14 October; Full Allotment: 15 October - 30 October.

Table 19: Number of Loans Obtained and Provided explained by Weighted In-Degree

	(1)	(2)	(3)	(4)
Pre-Lehman	-0.335	-0.338	-0.350	-0.310
	(0.261)	(0.260)	(0.257)	(0.244)
Post-Lehman	0.328	0.325	0.302	0.430
	(0.268)	(0.268)	(0.310)	(0.297)
SRO	-0.056	-0.061	-0.242	0.285
	(0.453)	(0.453)	(0.444)	(0.418)
Full Allotment	-0.736*	-0.739*	-0.739	0.016
	(0.440)	(0.441)	(0.513)	(0.482)
Relative Size	1.070***	0.855***	0.909***	-0.130
	(0.342)	(0.305)	(0.341)	(0.306)
Loan Loss Reserves	0.000	0.000	0.000*	0.000
	(0.000)	(0.000)	(0.000)	(0.000)
Assets	0.000	0.000	0.000*	0.000
	(0.000)	(0.000)	(0.000)	(0.000)
Weighted In-Degree		0.0003***		0.0004***
		(0.000)		(0.000)
(Weighted In-Degree × Date)				
Pre-Lehman				0.000
				(0.000)
Post-Lehman				-8.5e-5*
				(0.000)
SRO				-0.0002***
				(0.000)
Full Allotment				-0.0003***
				(0.000)
Controls × date	No	No	Yes	Yes
N	4348	4348	4348	4348
R^2 (within)	0.015	0.015	0.041	0.074
R^2 (between)	0.003	0.165	0.002	0.091
R^2 (overall)	0.001	0.074	0.001	0.046

Note: The dependent variable is $\#\text{Loans}_{i,t}$, i.e. the number of interbank loans a bank i obtains on the interbank market on day t. The explanatory variable is i's total interbank borrowing Weighted In-Degree during an initial reference period. We use the following bank-specific controls, all reported at the end of 2007. The relative size is the amount of interbank lending during the initial reference period divided by the total asset size. The Loan Loss Reserves are a proxy for the bank's riskiness and Assets is the total asset size. Date indicates a period dummy that is one in the respective period, and zero otherwise. The dates for the periods are as follows. Init: 04 July - 21 July; Pre-Lehman: 28 August - 12 September; Post-Lehman: 15 September - 29 September; SRO: 30 September - 14 October; Full Allotment: 15 October - 30 October.

Table 20: Number of Loans Provided and Obtained explained by Betweenness Centrality

	(1)	(2)	(3)	(4)
Pre-Lehman	-0.335	-0.336	-0.350	-0.313
	(0.261)	(0.260)	(0.257)	(0.260)
Post-Lehman	0.328	0.327	0.302	0.165
	(0.268)	(0.267)	(0.310)	(0.287)
SRO	-0.056	-0.059	-0.242	0.042
	(0.453)	(0.452)	(0.444)	(0.434)
Full Allotment	-0.736*	-0.737*	-0.739	-0.350
	(0.440)	(0.439)	(0.513)	(0.456)
Relative Size	1.070***	0.676**	0.909***	0.304
	(0.342)	(0.287)	(0.341)	(0.285)
Loan Loss Reserves	0.000	0.000	0.000*	-0.001*
	(0.000)	(0.000)	(0.000)	(0.000)
Assets	0.000	0.000	0.000*	0.000*
	(0.000)	(0.000)	(0.000)	(0.000)
Betweenness		253.659***		297.845***
		(64.621)		(68.367)
(Betweenness × Date)				
Pre-Lehman				-10.101
				(31.786)
Post-Lehman				2.065
				(27.173)
SRO				-65.490*
				(38.226)
Full Allotment				-99.634**
				(41.214)
Controls × date	No	No	Yes	Yes
N	4348	4348	4348	4348
R^2 (within)	0.015	0.015	0.041	0.057
R^2 (between)	0.003	0.389	0.002	0.323
R^2 (overall)	0.001	0.229	0.001	0.215

Note: The dependent variable is $\#\text{Loans}_{i,t}$, i.e. the number of interbank loans a bank i obtains on the interbank market on day t. The explanatory variable is the betweenness centrality of bank i (both perspectives) during an initial reference period. We use the following bank-specific controls, all reported at the end of 2007. The relative size is the amount of interbank lending during the initial reference period divided by the total asset size. The Loan Loss Reserves are a proxy for the bank's riskiness and Assets is the total asset size. Date indicates a period dummy that is one in the respective period, and zero otherwise. The dates for the periods are as follows. Init: 04 July - 21 July; Pre-Lehman: 28 August - 12 September; Post-Lehman: 15 September - 29 September; SRO: 30 September - 14 October; Full Allotment: 15 October - 30 October.

Table 21: Number of Loans Obtained and Provided explained by Katz-Centrality

	(1)	(2)	(3)	(4)
Pre-Lehman	-0.335	-0.339	-0.350	-0.199
	(0.261)	(0.261)	(0.257)	(0.274)
Post-Lehman	0.328	0.325	0.302	0.237
	(0.268)	(0.268)	(0.310)	(0.301)
SRO	-0.056	-0.062	-0.242	-0.059
	(0.453)	(0.452)	(0.444)	(0.439)
Full Allotment	-0.736*	-0.741*	-0.739	-0.686
	(0.440)	(0.440)	(0.513)	(0.509)
Relative Size	1.070***	1.063***	0.909***	0.850***
	(0.342)	(0.333)	(0.341)	(0.330)
Loan Loss Reserves	0.000	0.000	0.000*	0.000*
	(0.000)	(0.000)	(0.000)	(0.000)
Assets	0.000	0.000	0.000*	0.000
	(0.000)	(0.000)	(0.000)	(0.000)
Katz		15.970***		16.394**
		(4.848)		(7.580)
(Katz × Date)				
Pre-Lehman				-7.322
				(5.495)
Post-Lehman				-0.103
				(5.216)
SRO				-7.751
				(7.388)
Full Allotment				-3.037
				(7.168)
Controls × date	No	No	Yes	Yes
N	4348	4348	4348	4348
R^2 (within)	0.015	0.015	0.041	0.045
R^2 (between)	0.003	0.048	0.002	0.013
R^2 (overall)	0.001	0.016	0.001	0.003

Note: The dependent variable is $\#\text{Loans}_{i,t}$, i.e. the number of interbank loans a bank i obtains on the interbank market on day t. The explanatory variable is the Katz centrality of bank i (both perspectives) during an initial reference period. We use the following bank-specific controls, all reported at the end of 2007. The relative size is the amount of interbank lending during the initial reference period divided by the total asset size. The Loan Loss Reserves are a proxy for the bank's riskiness and Assets is the total asset size. Date indicates a period dummy that is one in the respective period, and zero otherwise. The dates for the periods are as follows. Init: 04 July - 21 July; Pre-Lehman: 28 August - 12 September; Post-Lehman: 15 September - 29 September; SRO: 30 September - 14 October; Full Allotment: 15 October - 30 October.

B.2 Do Borrower or Lender Characteristics Determine Liquidity Access or Provision?

Since we are interested in bank's access to liquidity via the interbank market during times of distress, we focus on those bank-specific measures that possibly affect how much liquidity a bank is able to obtain. The most straightforward such measures are a bank's balance sheet characteristics, introduced in Section 5. We focus on a bank total asset size and the amount of loan loss reserves, both measured at the end of 2007 and obtained from Bankscope.

Following Afonso et al. (2011) we estimate the following specifications:

$$\text{Access}_{i,t} = \beta(\text{Date}) + \delta(\text{Date} \times \text{Loan Loss Reserves}_{i,2007}) + \gamma(\text{Date} \times \text{Assets}_{i,2007}) + \epsilon_{i,t} \quad (21)$$

where $\text{Access}_{i,t}$ equals one if bank i borrowed on the interbank market on day t, i.e.:

$$\text{Access}_{i,t} = \max_j \{g_{ij,t}\}. \quad (22)$$

$\text{Assets}_{i,2007}$ are the assets of bank i at the end of 2007, and $\text{Loan Loss Reserves}_{i,2007}$ is the amount of loan loss reserves at the end of 2007.[25]

We also estimate an OLS regression for both maturity segments m (i.e. overnight and term, where term denotes all loans with a maturity longer than overnight and up to one year) with dependent variable $F^m_{i,t} = \{$amount borrowed, spread to the mean interbank interest rate, number of counterparties$\}$. The amount borrowed by bank i in maturity segment m at

[25] Loan loss reserves provide information on the perceived riskiness by banks of their loan portfolio: banks anticipating higher losses should hold higher liquidity buffers. We also used the ratio of non-performing to total loans and our results were qualitatively unchanged. The coverage of loan loss reserves is slightly better, though, so we use it in our main regressions.

time t is defined as:

$$\text{Amount}^{\text{m}}_{i,t} = \sum_{j \in B_{i,t}} \text{Loan}^{\text{m}}_{ji,t}. \tag{23}$$

The amount of interbank liquidity is only one aspect of the intensive margin of obtaining interbank liquidity. The other aspect is the price a bank pays for liquidity, measured as the spread to the main refinancing rate (in the overnight segment) or the average interbank interest rate (for the maturity segments). For each point in time t and each maturity segment we have a network G^{m}_t. Denote the price of a loan from i to j at time t with maturity m as $p^m_{ij,t}$ and the volume-weighted price in maturity segment m as $\widehat{\text{p}}^m_{ij,t}$. Then:

$$\widehat{\text{p}}^m_{ij,t} = p^m_{ij,t} \times \frac{\text{Loan}^m_{ij,t}}{\sum_{j \in B_{i,t}} \text{Loan}^m_{ij,t}}. \tag{24}$$

The spread to the mean interbank interest rate that borrower i pays on the interbank market at time t in maturity m is defined as:

$$\text{Spread}^{m,b}_{i,t} = \sum_{j \in B_{i,t}} \widehat{\text{p}}^m_{ij,t} - \widehat{\text{p}}^m_t. \tag{25}$$

where $\widehat{\text{p}}^m_t$ is the average interbank interest rate in maturity segment m at time t, $\widehat{\text{p}}^{\text{m}}_t = \sum_i \sum_{j:i} \widehat{\text{p}}^m_{ij,t}$.[26]

Using these definitions, we can specify OLS estimations that take borrower properties into account as:

$$\begin{aligned} F_{i,t} \;=\; & \beta(\text{Date}) + \delta(\text{Date} \times \text{Loan Loss Reserves}_{i,2007}) + \gamma(\text{Date} \times \text{Assets}_{i,2007}) \\ & + \Theta\left(\frac{\text{Amount}_{i,t}}{\text{Assets}_{i,2007}}\right) + \alpha_i + \epsilon_{i,t} \end{aligned} \tag{26}$$

[26] The computation for the average interest rate was done in three maturity segment separately to ensure comparable results across maturities. Loans in the three segments have maturity m with: 1day $< m \leq$ 1week ; 1week $< m \leq$ 3month ; 3month $< m <$ 1year.Differently from the term maturities, the spread for the overnight maturity is defined relative to the main refinancing rate.

where $\text{Amount}_{i,t}$ is the amount borrowed by bank i in both maturity segments and α_i are bank fixed effects. As before, the sample period runs from 04 July 2008 to 30 October 2008. In Tables (22) to (25) we split our sample in two subsamples based on banks' asset size. Large banks are in the upper tercile of the asset size distribution, while small banks are in the lower tercile. Furthermore, interacting the period dummies with borrower quality, measured by a bank i's loan loss reserves yields a triple difference-in-difference estimation that tests whether the interbank market has become sensitive to bank characteristics post-crisis and whether the sensitivity is greater for large or small banks.

As pointed out by Afonso et al. (2011), if lenders respond to the crisis by hoarding liquidity, we would expect to find an aggregate decrease in amounts lent and worse performing banks lending less. If instead uncertainty about counterparty risk increases after a shock but banks can still discriminate between risks, then we would expect to find a large shift in the distribution of funds and rates in the cross section of borrowers and worse performing banks borrowing less and/or paying higher rates. The aggregate view of market developments taken so far allows us to exclude an aggregate decrease in amounts lent after the bankruptcy of Lehman (with the only exception of the reduction on Tuesday 09/16 in the term segment). Moreover, in Table 12 we saw that bank-specific characteristics drove a relatively high increase in overnight and term borrowing rates and a reduction in the number of counterparties from which banks could obtain liquidity. Only in the term segment these developments are associated to a generalized decrease in borrowed amounts. This overall picture seems consistent with an increase in counterparty risk in the euro area interbank market around the Lehman event, especially in the ovenight segment, and a more pronounced market freeze only in the term segment.

Tables (22) and (23) corroborate and shed further light on this picture. Access to the market is reduced on Monday 15 and Tuesday 16, and especially so for small borrowers and for the overnight segment (models (1) and (2)). In models (3) and (4) we add interactions of

the period dummies with loan loss reserves as a proxy for borrower quality. The interaction terms reveal that large borrowers whose loan portfolio is riskier pre-crisis access the overnight market less, both around the Lehman event and afterwards. No such effect is visible for small borrowers. In contrast, in the term segment large, worse performing borrowers are found to actually increase their participation pre-Lehman and especially on Tuesday 16 September (model (7)). Evidence from Table (23) confirms that there was no decrease in amounts borrowed overnight around Lehman, not even for the worse performing banks. The significant and large coefficient on the large banks for the full-allotment period in model (3) tells us that it was large borrowers who strongly reduced their interbank funding after the Eurosystem switched to full-allotment operations in mid-October 2008. It were small banks that reduced their interbank funding in the term segment on Monday 15 September and in the full-allotment regime, instead.

Table (24) shows that both large and small banks see an increase in overnight spreads on Monday 15 September. However, the increase persists only for small banks on Tuesday 16 September, while large banks actually start borrowing at a discount, relative to the initial reference period, both in the post-Lehman period and especially after the ECB measures (SRO and full-allotment). When we add interactions of the period dummies with loan loss reserves, models (3) and (4), we still observe the increase in spreads on Monday 15 September (larger for small banks), but we do not see a significant deterioration of borrowing terms for small worse performing banks immediately after the Lehman event. The only significant and positive coefficient appears for the interaction between loan loss reserves and the SRO period dummy, which suggests that small banks with a riskier loan portfolio pre-crisis could not obtain all the liquidity they needed at the Eurosystem's special refinancing operation. For the term segment, models (5) to (8) show that immediately after the crisis the relationship between spreads and borrower quality was not significantly different from that for the pre-crisis period, i.e. interest rates in the term segment did not become increasingly sensitive to

measures of borrower quality.

We find similar evidence in Table (25) for the number of counterparties a bank borrows from. The results do not provide strong evidence of a changed market sensitivity of to borrower size, nor to borrower quality immediately after the Lehman insolvency. The only significant and economically sizeable effect can be observed after the adoption of the full-allotment regime on 15 October, when large banks reduce the number of counterparties from which they borrow (-2.6 counterparties in model (1) and -3.4 in model (3)). A similar effect is found in the term segment, again for large banks, but this effect is not as large as in the overnight segment.

Overall, these tables do not show a drastic change in the distribution of loans and rates in the cross section of borrowers depending on borrower pre-crisis quality, at least not immediately after the Lehman insolvency. This does not mean, however, that the market was not sensitive to counterparty risks, as we have shown in the aggregate perspective in Table (12). In a situation of stress, lenders may rather start to manage their unsecured interbank exposures by the amount they lend to a particular bank or even whether they lend to a given bank at all. Bank-to-bank relationships may actually become more important for the lenders' decision because they convey *soft* information that cannot be otherwide obtained from pre-crisis balance sheets. But this means that a more granular analysis of bilateral links between banks is needed. This motivates our network view in the rest of the paper.

Table 22: Impact of Lehman Event on Borrower Access

	Overnight				Term			
	Large	Small	Large	Small	Large	Small	Large	Small
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Pre-Lehman	-0.107	-0.125*	-0.193**	-0.141	0.041	0.090	0.131	0.062
	(0.066)	(0.073)	(0.084)	(0.134)	(0.071)	(0.074)	(0.082)	(0.105)
Monday 09/15	-1.332***	-1.678***	-1.393***	-1.569***	-1.226***	-1.401***	-1.078***	-1.342***
	(0.112)	(0.098)	(0.131)	(0.154)	(0.129)	(0.121)	(0.174)	(0.173)
Tuesday 09/16	-1.409***	-1.760***	-1.484***	-1.784***	-1.669***	-1.639***	-1.437***	-1.462***
	(0.120)	(0.088)	(0.139)	(0.144)	(0.117)	(0.154)	(0.149)	(0.211)
Post-Lehman	-0.145*	-0.171**	-0.283***	-0.127	-0.182***	-0.156**	-0.251***	-0.089
	(0.080)	(0.071)	(0.094)	(0.126)	(0.065)	(0.075)	(0.072)	(0.102)
SRO	-0.055	-0.176**	-0.141	-0.108	-0.174**	-0.106	-0.181	0.002
	(0.097)	(0.088)	(0.115)	(0.139)	(0.080)	(0.081)	(0.114)	(0.117)
Full-allotment	-0.239**	-0.275***	-0.336***	-0.237	-0.060	-0.166*	-0.073	-0.188
	(0.106)	(0.096)	(0.128)	(0.162)	(0.083)	(0.093)	(0.114)	(0.134)
Pre-Lehman×Loan Loss Reserves			-0.00001**	-0.001			0.00002***	0.001
			(0.000)	(0.001)			(0.000)	(0.001)
Monday 09/15×Loan Loss Reserves			-0.00004*	-0.003			0.000	0.003
			(0.000)	(0.002)			(0.000)	(0.002)
Tuesday 09/16×Loan Loss Reserves			-0.00004**	-0.002			0.00005***	-0.001
			(0.000)	(0.002)			(0.000)	(0.002)
Post-Lehman×Loan Loss Reserves			-0.00001***	-0.001			0.000	-0.001
			(0.000)	(0.001)			(0.000)	(0.001)
SRO×Loan Loss Reserves			-0.00001**	-0.001			-0.000	0.001
			(0.000)	(0.001)			(0.000)	(0.001)
Full-allotment×Loan Loss Reserves			-0.00001***	-0.001			0.000	-0.000
			(0.000)	(0.002)			(0.000)	(0.001)
Fixed Effects	No	No	No	No	No	No	No	No
N	2,617	2,618	2,617	2,618	1,828	1,838	1,828	1,838

Note: Impact of the Lehman event on borrowers. Term segment includes all loans with a maturity of longer than one day and up to one year. Large (small) banks are in the upper (lower) tercile of Assets_{2007}. The dates for the periods are as follows. Init: 04 July - 21 July; Pre: 28 August - 12 September; Monday: 15 September; Tuesday: 16 September; Post: 17 September - 29 September; SRO: 30 September - 14 October; Full: 15 October - 30 October.

Table 23: Impact of Lehman Event on Amount Borrowed

	Overnight				Term			
	Large (1)	Small (2)	Large (3)	Small (4)	Large (5)	Small (6)	Large (7)	Small (8)
Pre-Lehman	-15.897	-31.272	-121.607	-19.971	-11.781	0.013	0.597	-1.826
	(83.580)	(27.379)	(122.829)	(44.188)	(20.781)	(3.789)	(24.867)	(4.006)
Monday 09/15	50.663	-44.416	162.055	4.311	-28.681	-7.505*	22.506	-11.111*
	(146.412)	(31.025)	(146.990)	(36.883)	(29.299)	(4.345)	(29.048)	(6.472)
Tuesday 09/16	-118.438	-62.499	270.409	-49.364	-25.449	-5.061	-26.910	-6.057
	(138.670)	(46.566)	(188.503)	(70.471)	(24.296)	(6.718)	(24.563)	(8.063)
Post-Lehman	99.841	-19.466	115.431	-19.180	-28.564	-3.491	-27.411	-5.027
	(101.786)	(27.104)	(107.064)	(37.730)	(23.021)	(3.947)	(23.565)	(3.719)
SRO	102.118	-41.257	-57.506	-13.249	-11.825	-5.289	-3.275	-6.106
	(108.614)	(32.738)	(105.887)	(42.819)	(24.458)	(3.808)	(28.265)	(4.552)
Full-allotment	-75.521	-46.039	-331.0**	-36.074	-30.793	-2.969	-6.050	-14.609***
	(125.772)	(27.985)	(134.859)	(40.637)	(31.499)	(3.707)	(28.912)	(5.524)
Pre-Lehman×Loan Loss Reserves			-0.004	0.008			0.001	0.014
			(0.021)	(0.205)			(0.005)	(0.051)
Monday 09/15×Loan Loss Reserves			-0.033	-0.272			-0.005	0.009
			(0.026)	(0.240)			(0.004)	(0.046)
Tuesday 09/16×Loan Loss Reserves			-0.056	0.139			-0.004	-0.008
			(0.042)	(0.316)			(0.006)	(0.157)
Post-Lehman×Loan Loss Reserves			-0.005	0.200			0.000	0.009
			(0.021)	(0.186)			(0.005)	(0.060)
SRO×Loan Loss Reserves			-0.004	0.044			-0.003	0.030
			(0.022)	(0.191)			(0.006)	(0.065)
Full-allotment×Loan Loss Reserves			-0.005	0.062			0.001	0.140*
			(0.022)	(0.199)			(0.006)	(0.081)
Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
N	2,409	1,810	2,409	1,810	1,560	874	1,560	874
Adjusted R^2	0.770	0.595	0.776	0.645	0.757	0.545	0.761	0.545

Note: Impact of the Lehman event on borrowers. Term segment includes all loans with a maturity of longer than one day and up to one year. Large (small) banks are in the upper (lower) tercile of Assets_{2007}. The dates for the periods are as follows. Init: 04 July - 21 July; Pre: 28 August - 12 September; Monday: 15 September; Tuesday: 16 September; Post: 17 September - 29 September; SRO: 30 September - 14 October; Full: 15 October - 30 October.

Table 24: Impact of Lehman Event on Spreads

	Overnight				Term			
	Large (1)	Small (2)	Large (3)	Small (4)	Large (5)	Small (6)	Large (7)	Small (8)
Pre-Lehman	0.024***	0.020*	-0.000	0.049**	0.006	0.006	0.011	0.006
	(0.008)	(0.012)	(0.020)	(0.021)	(0.008)	(0.007)	(0.011)	(0.013)
Monday 09/15	0.157***	0.158***	0.142***	0.165***	0.005	0.064	0.008	0.092
	(0.011)	(0.021)	(0.026)	(0.037)	(0.011)	(0.056)	(0.015)	(0.095)
Tuesday 09/16	-0.021	0.133***	-0.007	0.125***	0.041	0.026	0.083	0.035
	(0.026)	(0.026)	(0.035)	(0.045)	(0.031)	(0.017)	(0.062)	(0.028)
Post-Lehman	-0.076***	0.025	-0.123***	0.018	0.017**	0.030**	0.030*	0.009
	(0.017)	(0.017)	(0.027)	(0.029)	(0.008)	(0.013)	(0.011)	(0.014)
SRO	-0.132***	0.061	-0.224***	-0.006	0.052***	0.061***	0.056***	0.070***
	(0.031)	(0.039)	(0.035)	(0.062)	(0.009)	(0.012)	(0.012)	(0.019)
Full-allotment	-0.296***	-0.126***	-0.358***	-0.119	0.031**	0.011	0.042**	-0.000
	(0.020)	(0.043)	(0.026)	(0.083)	(0.013)	(0.010)	(0.016)	(0.013)
Pre-Lehman×Loan Loss Reserves			0.000	-0.0003**			-0.000	-0.000
			(0.000)	(0.000)			(0.000)	(0.000)
Monday 09/15×Loan Loss Reserves			0.000	0.000			-0.000	-0.000
			(0.000)	(0.000)			(0.000)	(0.000)
Tuesday 09/16×Loan Loss Reserves			-0.000	0.000			-0.000005*	-0.000
			(0.000)	(0.000)			(0.000)	(0.000)
Post-Lehman×Loan Loss Reserves			0.000	0.000			-0.000001*	0.000
			(0.000)	(0.000)			(0.000)	(0.000)
SRO×Loan Loss Reserves			0.000	0.001**			-0.000	-0.000
			(0.000)	(0.000)			(0.000)	(0.000)
Full-allotment×Loan Loss Reserves			0.000	-0.000			-0.00002***	0.000
			(0.000)	(0.001)			(0.000)	(0.000)
Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
N	2,409	1,810	2,409	1,810	1,560	874	1,560	874
Adjusted R^2	0.333	0.480	0.346	0.488	0.207	0.410	0.206	0.418

Note: Impact of the Lehman event on borrowers. Term segment includes all loans with a maturity of longer than one day and up to one year. Large (small) banks are in the upper (lower) tercile of Assets_{2007}. The dates for the periods are as follows. Init: 04 July - 21 July; Pre: 28 August - 12 September; Monday: 15 September; Tuesday: 16 September; Post: 17 September - 29 September; SRO: 30 September - 14 October; Full: 15 October - 30 October.

Table 25: Impact of Lehman Event on Number of Counterparties

	Overnight				Term			
	Large (1)	Small (2)	Large (3)	Small (4)	Large (5)	Small (6)	Large (7)	Small (8)
Pre-Lehman	-0.615	0.117	-1.206	0.550	-0.262	0.183	-0.056	0.408
	(0.468)	(0.576)	(1.053)	(1.163)	(0.185)	(0.304)	(0.261)	(0.591)
Monday 09/15	0.201	0.034	1.242	0.606	-0.566**	-0.143	-0.155	-0.026
	(0.780)	(0.621)	(0.895)	(1.153)	(0.219)	(0.303)	(0.260)	(0.489)
Tuesday 09/16	-1.316*	-0.283	0.430	0.128	-0.420	-0.032	-0.402	0.317
	(0.715)	(0.515)	(1.015)	(0.778)	(0.423)	(0.386)	(0.550)	(0.741)
Post-Lehman	0.628	0.450	-0.582	0.962	-0.585*	0.190	-0.298	0.580
	(0.457)	(0.363)	(0.983)	(0.687)	(0.298)	(0.467)	(0.277)	(0.838)
SRO	-0.551	0.415	-1.564	1.074	-0.858**	-0.098	-0.230	0.112
	(1.063)	(0.467)	(0.824)	(0.847)	(0.352)	(0.167)	(0.337)	(0.339)
Full-allotment	-2.615***	-0.081	-3.393***	0.450	-0.748**	-0.329	-0.453	-0.543
	(0.849)	(0.536)	(1.261)	(1.099)	(0.334)	(0.265)	(0.322)	(0.446)
Pre-Lehman×Loan Loss Reserves			0.000	-0.004			0.000	-0.002
			(0.000)	(0.006)			(0.000)	(0.003)
Monday 09/15×Loan Loss Reserves			-0.000	-0.006			-0.000	-0.001
			(0.000)	(0.007)			(0.000)	(0.003)
Tuesday 09/16×Loan Loss Reserves			-0.000	-0.004			-0.000	-0.005
			(0.000)	(0.004)			(0.000)	(0.005)
Post-Lehman×Loan Loss Reserves			0.000	-0.005			0.000	-0.005
			(0.000)	(0.004)			(0.000)	(0.005)
SRO×Loan Loss Reserves			0.000	-0.005			0.000	-0.002
			(0.000)	(0.004)			(0.000)	(0.002)
Full-allotment×Loan Loss Reserves			0.000	-0.005			0.00005**	0.002
			(0.000)	(0.006)			(0.000)	(0.003)
Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
N	2,409	1,810	2,409	1,810	1,560	874	1,560	874
Adjusted R^2	0.735	0.722	0.738	0.724	0.453	0.275	0.494	0.267

Note: Impact of the Lehman event on borrowers. Term segment includes all loans with a maturity of longer than one day and up to one year. Large (small) banks are in the upper (lower) tercile of Assets_{2007}. The dates for the periods are as follows. Init: 04 July - 21 July; Pre: 28 August - 12 September; Monday: 15 September; Tuesday: 16 September; Post: 17 September - 29 September; SRO: 30 September - 14 October; Full: 15 October - 30 October.

B.3 Can Nodes Influence their own Centrality?

In Khwaja and Mian (2008) banks experience an exogenous liquidity shock due to sanctions imposed on Pakistan following an unannounced nuclear weapon's test. This exogenous shock is crucial for identification and begs the question whether a change in a node's network centrality can be seen as exogenous. We use three shocks in this paper: the insolvency of the US investment bank Lehman Brothers on 15 September 2008 (our main specification), the first full-allotment special refinancing operation on 29 September, and the decision by the Eurosystem to move from a variable-rate auction-based regime of monetary policy to a full-allotment regime on 15 October 2008. Our main hypothesis is that banks in a more central position within the network have easier access to more and cheaper liquidity. We show in Section 2 that the interbank network structure changes significantly between the different sample periods. This aggregate change causes substantial change in individual banks' network position (measured by their degree, volume, and centralities). We test the hypothesis that this change in bank i's network position leads to a change in i's liquidity provision and access using a diff-in-diff setting similar to Khwaja and Mian (2008).

However, one concern could be that banks can strategically choose their network position. A change in their network position would thus not be an exogenous shock. In this section we thus test whether banks can indeed strategically choose a certain value of their centrality. Intuitively, we expect this not to be the case because a bank's centrality depends on the entire network structure, while the bank can only decide about its immediate neighborhood (i.e. whether to form a link with other banks and thus add them to the neighborhood). While there is no easy analytical proof of our intuition, we can test it numerically.

Consider the following simple algorithm with seven steps:

1. Select an undirected random network with N nodes. Since interbank networks are

typically of core-periphery type, we draw N_G core-periphery networks G with N nodes. [27].

2. Select N_r random reference nodes r.

3. Calculate the initial centrality of the reference node C_r^i where $C \in \{\text{Betweenness}, \text{Katz}\}$.

4. Add N_m random links to/from the reference node r.

5. Allow the rest of the network to change: select N_{-r} random nodes in the network and change a random number of links of these, that are not to/from the reference node r.

6. Now calculate the updated centrality of the reference node C_r^u and compute the absolute change in the centrality (relative to the initial centrality):

$$\Delta C_r = \left| \frac{C_r^u - C_r^i}{C_r^i} \right|.$$

7. Calculate the mean of ΔC_r.[28].

We perform the numerical simulation both for core-periphery network configuration and for Erdös-Rényi network with rewiring probability equal to 0.8. Choosing a high value for the last parameter, we aim to reflect the empirical evidence that interbank market structure is relatively tightly knit. As it has been argued by Haldane (2009) indeed, the financial sector has undergone increasing levels of homogeneity. Moreover, several empirical papers

[27] In line with the evidence commonly found in the empirical literature on interbank networks, we set the number of cores for each network randomization to be chosen randomly between $10 - 20\%$ of the total number of nodes

[28] Technically, in the numerical simulation we compute three averages. First, we calculate the average change in the reference node centrality induced by othersâĂŹ links change over N_m different links randomizations of the reference node r. The calculation of this average is performed for N_r random reference nodes selected (using the same initial network configuration selected in step 1.) and the mean of these averages is calculated over N_G random configurations of the network. This last average gives the value for ΔC_r for each given number of nodes.

show that bank networks feature a core-periphery structure with a core of big and densely connected banks and a periphery of smaller banks. Our hypothesis aims therefore to capture the opportunity for banks in this core to change their network position.

In Figure 5 we show the change in the centrality measures of node r in a log scale and do linear fit, which corresponds to an exponential increase in the mean of ΔC_r. We obtain in general a good level of the linear fit of the two series in log scale, as shown by the R-square values of 0.92 and 0.72 calculated respectively for the core-periphery and the Erdös-Rényi network. This implies that increasing network size, the change in a node r's centrality due to changes outside of the neighborhood of r increases more than the change in r's centrality due to changes in the neighborhood of r. Accordingly, the results of the analysis support our intuition that nodes cannot influence their centrality and strategically choose their network position.

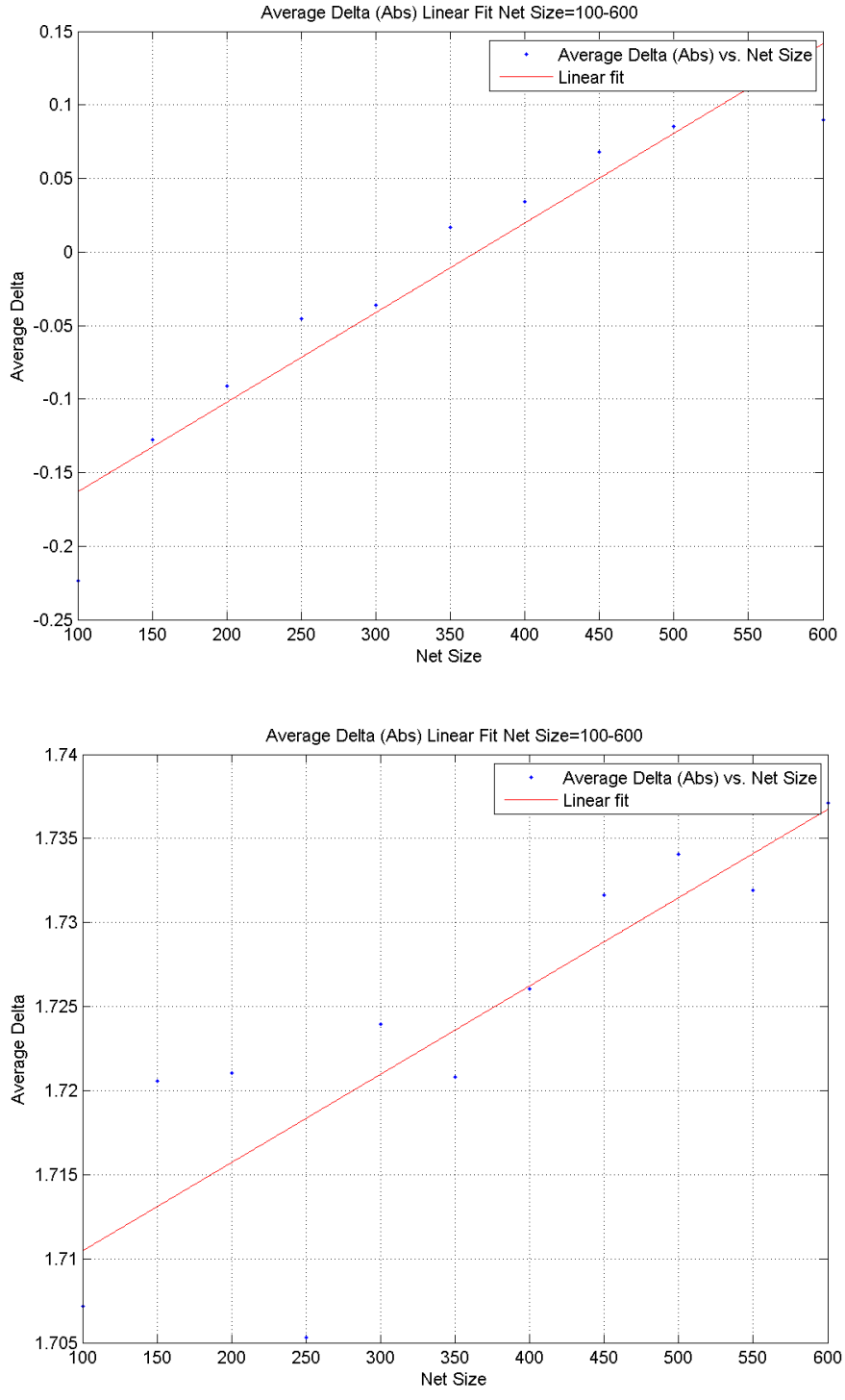

Figure 5: Mean relative change ΔC_r in node r's centrality versus network size. Mean is computed over $N_G = 100$ random draws, $N_r = 10$ random reference nodes that can randomly change $N_m = 10$ links, and $N_{-r} = 1$ random changes of links outside r's neighborhood. We use core-periphery network (top) and Erdös-Rényi network with rewiring probability equal to 0.8 (bottom).