The Influence of China's Interbank Network with Connection Tendency on Net Stable Funding Ratio

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Abstract. The interbank with connection tendency is constructed by cross-entropy algorithm with local iterations. The local and global network topological characteristics of banks are analyzed. The direct lending relationship formed by short-term bilateral lending between banks and the overall status brought by the lending relationship have significant impacts on the stability of banks' long-term capital structure.

Keywords: Net stable funding ratio · Interbank lending network · Connection tendency

1 Interbank Lending Network with Connection Tendency

Banks with the same connection tendency will form a community and prefer inter community lending [1]. Due to regional and capital openness, the banking systems of many countries and regions have a tendency of regional connection [2, 3]. Due to China's financial regulatory system, the inter-bank network of each province has a community structure, and the inter-bank links within the community are closer [1]. Banks with fewer contacts are more likely to conduct interbank lending transactions with banks with more contacts [4]. Small banks often do not lend money to other small banks, but will have debt transactions with large and reputable banks [5]. Therefore, considering the regional and attribute heterogeneity of interbank lending preference, this paper estimates the direction and weight of interbank lending relationship based on cross entropy minimization as follows:

Take the total amount borrowed from interbank as the column constraint and the total amount lent to interbank as the row constraint. Cross entropy minimization is used to estimate the weight of inter-bank lending relationship, as shown in formula 1.

$$\min C(L, E) = \min(\sum_{i,j=1}^{N} l_{ij} \ln(\frac{l_{ij}}{e_{ij}})) \tag{1}$$

S. H. B. D. M. Zailani et al. (Eds.): ICMSEM 2023, 259, pp. 1219–1225, 2024.
https://doi.org/10.2991/978-94-6463-256-9_124

And satisfy the constraints:

$$\begin{cases} \sum_i l_{ij} = In_j \\ \sum_j l_{ij} = Out_i \end{cases} i = 1, 2, ..., N; j = 1, 2, ..., N \tag{2}$$

where, l_{ij} represents the amount lent from bank i to bank j. $In_j = \sum_{i=1}^{N} l_{ij}$ represents the sum of all interbank borrowing in of bank j. $Out_i = \sum_{j=1}^{N} l_{ij}$ represents the sum of all interbank lending out of bank i, and N is the number of banks. If $e_{ij} = 0$, $l_{ij} = 0$ and $0 \ln(\frac{0}{0}) = 0$.

First, the interbank lending matrix L_1 is estimated for banks in the same province according to formula 1, $e_{ij} = 1$ means that bank i lends to bank j, and bank i and bank j belong to the same province. Then, for banks with the same attribute, the interbank lending matrix L_2 is estimated according to formula 1, $e_{ij} = 1$ indicating that bank i lends to bank j, and bank i and bank j belong to the same attribute. Then, the interbank lending matrix L_3 is estimated according to formula 1 among the remaining banks. Finally, the interbank lending matrix is superimposed to form the interbank lending network $L = L_1 + L_2 + L_3$.

When l_{ij} exceeds the threshold β, there is an interbank lending relationship between bank i and bank j. If the threshold β exceeds 0.001, about 75% of the edges of the interbank network are filtered. The number of edges and graph density of bank lending network decrease significantly, and the weak connected components increase significantly, but the change of reciprocity ratio is not obvious. Therefore, the subsequent analysis is set at threshold 0.001.

2 Model and Variables

$NSFR = \frac{\sum_i w_i L_i}{\sum_j w_j A_j}$ is dependent variable. The details of assets A_j and liabilities L_i in the balance sheet are weighted according to their stability [6, 7], as shown in Table 1.

The topology variables of interbank lending network measure the capital chain association of banks accessing the interbank market, which are divided into two types: local structure variables measure the situation and ability of banks to obtain interbank funds through direct trading partners. They include in degree (InD), out degree (OutD) and clustering coefficient (ClsT). The overall structure variables evaluate the interconnection and status of banks according to their location in the whole network. They include betweeness (BetW), in closeness (InC), out closeness (OutC), hub score (Hub), authority score (Aut) and page ranking (PagR). All network topology variables are calculated by the centrality function of MATLAB.

The bank level control variables are asset scale (BkSz), net interest margin (NIM), return on AVG equity (ROE), cost income ratio (CIR), recurring earning power (REP), return on assets and average return on net assets (ROA). The control variables at the provincial level are the natural logarithm of the provincial total import and export trade (ImEx) and the natural logarithm of the provincial total e-commerce sales (Esal).

Table 1. Bank balance sheet details and corresponding weight

Assets (A_j)	W_j	Liabilities & equity (L_i)	W_i
1 Total Earning Assets		1 Deposits & Short term funding	
1–1 Loans	100%	1–1 Total customer deposits	75%
1–2 Other Earning Assets		1–2 Deposits from banks	0%
1–2-1 Loans and Advances to Banks	0%	1–3 Other deposits and short-term borrowings	0%
1–2-2 Derivatives	35%	2 Other interest bearing liabilities	
1–2-3 Other Securities	35%	2–1 Derivative	0%
1–2-4 Remaining earning assets	35%	2–2 Trading Liabilities	0%
2 Fixed Assets	100%	2–3 Long term funding	100%
3 Non-Earning Assets		3 Other (Non-Interest bearing)	100%
3–1 Cash and Balances at Central Bank	0%	4 Loan Loss Reserves	100%
3–2 Good Will	100%	5 Reserves	100%
3–3 Other Intangibles	100%	6 Equity	100%

The research object is 151 banks with relatively complete asset liability information in BANKSCOPE and CSMA databases from 2015 to 2019. Banks are divided into five categories: urban commercial banks (UCB), rural commercial banks (RCB), joint-stock commercial banks (JSCB), state-owned holding banks (SOB) and central policy banks (CPB). The descriptive statistics of lending network topology variables and various variables are shown in Table 2.

$\mathrm{NSFR}_i^t = \alpha_0 + \alpha_1 Net_i^t + \sum_{k=1}^{6} \alpha_{2k} B_{i,k}^{t-1} + \sum_{k=1}^{2} \alpha_{3k} \mathrm{C}_{\mathrm{j,k}}^t + \sum_{k=1}^{4} \alpha_{4k} T_k^t + \mu_i + \varepsilon_i^t$ is used to test the impact of interbank lending network topology variables on NSFR. Where i = 1, 2…, N represents the bank number; t represents the year of the sample. Net_i^t is a network

Table 2. Descriptive Statistics of Variables

Variable	Mean	StD	Min	Max	Variable	Mean	StD	Min	Max
InD	4.9841	5.2297	0	36	NIM	2.6888	1.0572	-.1983	6.8322
OutD	4.9841	5.3893	0	39	ROE	12.6872	4.8699	-7.5055	31.6598
InC	.0004	.0003	0	.0016	CIR	37.6467	8.1986	6.8109	68.4444
OutC	.0004	.0003	0	.0017	REP	1.7883	.4756	.0697	3.6499
BetW	9.9205	58.2056	0	844.7667	ROA	1.0704	.4391	-.7078	3.1993
ClsT	.6503	.4152	0	1	BkSz	19.4954	1.5039	16.4914	24.1281
Hub	.0066	.0041	0	.0276	ImEx	16.4579	1.3181	12.6924	18.5018
Aut	.0066	.0041	0	.0234	Esal	8.4206	1.0246	4.7159	10.3145
PagR	.0066	.0056	.0011	.0496	NSFR	1.0968	.1389	.7596	1.6569

structure variable, which successively introduces in degree (InD), out degree (OutD), in closeness (InC), out closeness (OutC), clustering coefficient (ClsT), betweeness degree (BetW), hub score (Hub), authority score (Aut) and page rank (PagR). $B_{i,k}^{t-1}$ is the vector of bank control variables. When k takes 1 to 6, it means including net interest margin (NIM), average return on net assets (ROE), cost income ratio (CIR), recurring profitability (REP), return on assets (ROA) and bank asset scale (BkSz). In order to avoid possible endogeneity, t-1 period value is used for all bank control variables. $\mathrm{C}_{\mathrm{j,k}}^{t}$ is the vector of macro control variables, and j represents the province number to which bank i belongs. When k takes 1 to 2, it means the natural logarithm (ImEx) of the provincial total import and export trade and the natural logarithm (Esal) of the provincial total e-commerce sales. T_k^t is the vector of year dummy variable. When k takes 1 to 4, it means from 2016 to 2019.

3 Influences of Interbank Lending Network on NSFR

The panel regression of fixed effect and random effect of explanatory variables on the explained variables is carried out in table 3. According to Sargan-Hansen test, all fixed effect models are selected.

The greater the number of direct lending items a bank has in the interbank lending network, the lower its NSFR. The shorter the borrowing capital chain is, the lower their NSFR. Bank authorities have smaller NSFR.

The greater the number of direct borrowing items a bank has in the interbank lending network, the larger its NSFR. Banks with higher betweeness have larger NSFR. Bank hubs have larger NSFR.

The borrowing relationship of banks has a greater impact on NSFR than the lending relationship. Banks mainly rely on their own direct lending relationship. Only the partner capabilities involved in the direct lending relationship and their global position in the lending capital chain will have a significant impact on NSFR. The closer the lending partner is, the greater its impact on the bank NSFR, while the lending relationship between direct partners and that between distant partners have no significant impact on bank's NSFR.

Table 3. Influence of interbank lending network variables on NSFR

	NSFR(1)	NSFR(2)	NSFR(3)	NSFR(4)	NSFR(5)	NSFR(6)	NSFR(7)	NSFR(8)	NSFR(9)
InD ①	$-.2127^{***}$ (.0720)								
OutD ②		$.2019^{***}$ (.0686)							
InC ③			$-.0825^{**}$ (.0369)						
OutC ④				$.0624^{**}$ (.0297)					
ClsT ⑤					.0106 (.0315)				
BetW ⑥						$.0559^{***}$ (.0144)			
Hub ⑦							$.1255^{***}$ (.0387)		
Aut ⑧								$-.1683^{***}$ (.0456)	
PagR ⑨									-.0847 (.0523)
NIM ①	$-.1333^{*}$ (.0792)	-.1176 (.0826)	-.1312 (.0806)	-.1169 (.0825)	-.1188 (.0814)	-.1192 (.0815)	-.1243 (.0809)	-.1242 (.0808)	-.1237 (.0811)
ROE ②	$.3087^{***}$ (.0840)	$.3159^{**}$ (.0828)	$.3015^{***}$ (.0832)	$.3050^{***}$ (.0826)	$.3055^{***}$ (.0833)	$.3052^{***}$ (.0837)	$.3183^{***}$ (.0819)	$.2968^{***}$ (.0829)	$.3010^{***}$ (.0824)

(continued)

Table 3. (*continued*)

	NSFR(1)	NSFR(2)	NSFR(3)	NSFR(4)	NSFR(5)	NSFR(6)	NSFR(7)	NSFR(8)	NSFR(9)
CIR ③	.1348* (.0725)	.1289* (.0742)	.1379* (.0739)	.1384* (.0748)	.1391* (.0749)	.1347* (.0747)	.1353* (.0726)	.1235* (.0725)	.1326* (.0739)
REP ④	.1217 (.0924)	.1208 (.0969)	.1224 (.0939)	.1196 (.0952)	.1211 (.0952)	.1177 (.0962)	.1337 (.0952)	.1028 (.0938)	.1167 (.0934)
ROA ⑤	-.2257*** (.0718)	-.2410*** (.0722)	-.2240*** (.0722)	-.2199*** (.0716)	-.2242*** (.0719)	-.2225*** (.0729)	-.2439*** (.0705)	-.2145*** (.0712)	-.2239*** (.0709)
BkSz ⑥	-.4819 (.4296)	-1.1533*** (.4223)	-.6287 (.4157)	-.8921** (.4355)	-.7837* (.4401)	-.7961* (.4400)	-1.0142** (.4285)	-.5862 (.4345)	-.7048 (.4358)
ImEx ①	-.9237** (.3776)	-.8200** (.3787)	-.9447** (.3735)	-.8650** (.3820)	-.9011** (.3810)	-.8916** (.3838)	-.8545** (.3834)	-.9043** (.3679)	-.9237** (.3813)
Esal ②	.4212** (.1773)	.3567** (.1691)	.4087** (.1752)	.3794** (.1707)	.4061** (.1755)	.3930** (.1783)	.3628** (.1691)	.4231** (.1770)	.4151** (.1780)
2016 ①	-.2837*** (.0925)	-.2035** (.0926)	-.2730*** (.0910)	-.2295** (.0914)	-.2489*** (.0938)	-.2467** (.0945)	-.2127** (.0933)	-.2828*** (.0928)	-.2668*** (.0939)
2017 ②	-.4499*** (.1660)	-.3150** (.1551)	-.4388*** (.1618)	-.3414** (.1606)	-.3809** (.1646)	-.3824** (.1649)	-.3299** (.1565)	-.4479*** (.1671)	-.4136** (.1675)
2018 ③	-.6716*** (.2308)	-.4851** (.2143)	-.6350*** (.2247)	-.5356** (.2230)	-.5781** (.2274)	-.5783** (.2275)	-.5064** (.2161)	-.6675*** (.2321)	-.6176*** (.2317)
2019 ④	-.7351*** (.2704)	-.4951** (.2502)	-.6850*** (.2614)	-.5638** (.2608)	-.6171** (.2665)	-.6132** (.2669)	-.5320** (.2541)	-.7182*** (.2708)	-.6628** (.2706)
Constant	.4281*** (.1460)	.2997** (.1361)	.4064*** (.1416)	.3340** (.1409)	.3650** (.1444)	.3641** (.1446)	.3162** (.1376)	.4233** (.1468)	.3922*** (.1467)
R2	0.3794	0.3805	0.3732	0.3710	0.3688	0.3672	0.3793	0.3852	0.3711
F	20.92***	20.61***	20.54***	19.90	22.59***	19.66***	21.09***	21.57***	19.79***

Note: Coefficients (robust standard errors), *, * *, * * * represent 10%, 5%, and 1% significance levels

Acknowledgment. This work was supported by the Shanghai Philosophy and Social Sciences Fund (2019BGL003), Research on Risk Contagion of Information Technology Enterprise and Bank Dependent Network.

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