The Interbank Market Puzzle*

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First draft: September 2017

This draft: October 2019

* For helpful comments we thank Galina Hale (FMA discussant), Amanda Heitz (CICF discussant), Yiming Ma (WFA discussant), Zuzana Fungacova, Iftekhar Hasan, Yiming Qian, Zongxin Qian, Frans de Roon, and seminar and session participants at Penn (Economics), Federal Reserve Bank of Philadelphia, University of Bath, I*É*SEG School of Management, Central University of Finance and Economics, Banco de Portugal/European Investment Bank Conference on "Investment Finance and the Recovery", Bank of Finland/CEPR joint conference on "Money in the Digital Age", House of Finance, University Dauphine workshop on "Regulation and Systemic Risk", Financial Management Association Annual Meeting 2018, Western Finance Association Annual Meeting 2019, China International Conference in Finance 2019, Asian Finance Association Annual Meeting 2019.

Disclaimer: This paper should not be reported as representing the views of the European Central Bank (ECB) and of the Bank of England (BOE). The views expressed are those of the authors and do not necessarily reflect those of the ECB and the BOE.

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Abstract

This study documents significant differences in the interbank market lending and borrowing levels across countries. We argue that the existing differences in interbank market usage can be explained by the trust of the market participants in the stability of the country's banking sector and counterparties, proxied by the history of banking crises and failures. Specifically, banks originating from a country that has lower level of trust tend to have lower interbank borrowing. Using a proprietary dataset on bilateral exposures, we investigate the Euro Area interbank network and find the effect of trust relies on the network structure of interbank markets. Core banks acting as interbank intermediaries in the network are more significantly influenced by trust in obtaining interbank funding, while being in a community can mitigate the negative effect of low trust. Country-level institutional factors might partially substitute for the limited trust and enhance interbank activity.

JEL codes: G01, G21, G28

Key words: Interbank market, Trust, Networks, Centrality, Community detection

1. Introduction

The interbank market is an informal market where banks borrow from and lend to each other with established internal limits based on an institution's risk appetite. On one hand, the interbank market plays crucial roles in domestic financial systems because first, central banks intervene in this market to guide policy interest rates, and second, efficient liquidity transfer can occur between surplus and needy banks through a well-functioning interbank market (Furfine, 2001; Acharya et al., 2012). Moreover, theoretical studies suggest that interbank markets allow risk sharing (Bhattacharya and Gale, 1987). After the 2007–2009 global financial crisis, studies find that efficient risk sharing through the interbank market might not occur during crises due to moral hazard and market frictions in the lending market. In particular, the financial problems of investment bank Bear Sterns and the failure of Lehman Brothers showed that interbank markets can be an important channel of contagion. Interbank exposure might present a systemic risk to the stability of the financial system. The crisis events of 2007 resulted in a significant increase in market rates and a simultaneous decrease in transaction volume in the interbank market. According to Afonso et al. (2011), the situation in the interbank market can be explained by the increase in counterparty risk and precautionary liquidity hoarding in anticipation of future shortages.

On the other hand, we still know very little how the interbank market works, despite the existence of many recent studies on interbank market risk and interconnections. We know that the interbank market allows banks to adjust the volume of assets and liabilities as well as to manage the interest and exchange rate risks that arise from customer business. Hence, there is a great variation between banks in their use of the interbank market within each country's banking sector. Moreover, the average ratio of interbank activities to total bank positions seems to be quite stable over a long horizon (BIS, 1983). The difference, however, is the position of the interbank market across countries. The average ratio of loans to depository institutions to total assets of insured commercial banks in the United States (US) was 1.81% from 1934 to

2015,[1] while that for Germany was 20.61% from 1950 to 2015.[2] Figure 1 shows the average share of interbank lending and borrowing to commercial bank assets for the US, Japan, France, Germany, and the UK. During 2000-2014, the size of interbank lending as measured by the share of interbank lending to total assets was significantly higher in France and Germany than in Japan and US (2%-4%). Similarly, the size of interbank deposits as measured by the share of interbank deposits to total liabilities and equity was also significantly higher in France and Germany than in Japan and the US.

FIGURE 1A &1B

These data raise several important questions (the "puzzle") that have remained unexplored up to now. Why is there such a difference in the size of the interbank market across countries? What determines the participation of banks in the interbank market? Is risk sharing better in those countries with greater usage of the interbank market? Our study attempts to shed light on these questions by investigating the role of country-specific trust in banking systems in determining interbank participation as well as its relationship with the interbank network structure. Using the European Central Bank (ECB)'s confidential data on interbank bilateral large exposures for supervisory purposes, we are able to map and examine the network structure of Euro Area (EA) interbank market. The EU introduced the large exposure regime in 2014, which requires banks to report to authorities detailed information about their large exposures. To date the large exposures sample captures 90% of the EA banks' risk weighted assets vis-à-vis credit institutions.

In the interbank market, banks have a powerful incentive to monitor each other, as interbank deposits and loans are not insured and often uncollateralized (Furfine, 2001). Initially, the interbank market was an informal market of short-term placement of deposits (Bernard and Bisignano, 2000). Nowadays, the market is very international and banks located

[1] The data are from the US FDIC for insured commercial banks, available at: https://www5.fdic.gov/sdi/main.asp?formname=standard

[2] The data are from Deutsche Bundesbank, available at: http://www.bundesbank.de/Navigation/EN/Statistics/Banks_and_other_financial_institutions/Banks/banks.html

throughout the world participate in domestic market making as well as cross-border transactions. The main criteria for participation are that the bank establishes itself as creditworthy compared to other banks and is not constrained by domestic regulations. The transactions are arranged by the banks' dealers over the phone and the deal is confirmed by subsequent exchanges of confirmation between the banks. However, the dealer performs the transactions within limits, which are set up based on internal assessment of risk of counterparties. In the case of a failure, the interbank deposits are most likely to be lost, as they are not insured. Meanwhile, the likelihood that the bank will fail depends on its financial situation and the attitude of the supervisor authority and governments to bank failure. Rochet and Tirole (1996), however, highlight that peer monitoring can be weakened by government interventions.

In this study, we define trust as the subjective assessment of the stability of the banking sector and the risk of counterparties. Hence, trust varies strongly across institutions as well as countries, and its level can be influenced by the historical stability of the banking sector. Therefore, in order to measure trust, we use the history of banking crises and failures as a proxy.

Our investigation shows that, first of all, trust is crucial in determining the interbank market size. Higher trust helps banks to obtain liquidity in this unsecured market through mitigating information asymmetries about counterparty credit risk and developing lending relationships. If a bank is located in a country that has experienced longer periods of banking crisis or more bank failures in the past, trust can be weaker and support less interbank activities given the counterparty credit risk and the possible adverse selection in this market. This effect is present when we control for law enforcement, legal origin, and other country-level characteristics.

In order to address the endogeneity concern that some other country feature, for example, the structure of financial system, might affect the functions of the banking system as well as crises in the past (Allen et al., 2012), which could further influence interbank activities, we employ a matching algorithm to define a treated group of banks located in countries with the longest duration of banking crises and a control group of banks with comparable size, located

in the counties with the lowest duration of crises, yet similar financial structure. After the matching, we find the effect is still present while the economic impact of crises is even stronger.

It is also possible that the interbank borrowing might be influenced by other unobserved factors correlated to trust. To address this concern, we then employ instrumental variable (IV) analyses. The instruments we employ are the usage of deposit insurance scheme as well the power of deposit insurance scheme in a given country. Demirgic-Kunt et al. (2014) show that countries with a larger number of banking crises and failures are more likely to introduce a safety net, i.e. the deposit insurance, so the trust can be restored. The exclusive condition is also very likely to be satisfied as most of the interbank borrowing (deposit) is based on credit, and therefore not covered by deposit insurance (Furfine, 2001). The instrument variable analysis confirms our finding that lower level of trust in the banking system reduces interbank borrowing.

Second, legal and regulatory institutions play an important role in explaining the difference in interbank market participation at the country level. Numerous studies suggest that legal and institutional differences shape both the price and non-price terms of bank loans around the world (Qian and Strahan, 2007). Consistently, we find that these ex-post mechanisms in institutions can benefit the development of the interbank market. More importantly, these institutional factors can mitigate the adverse effect of crises on interbank activities and further help to restore trust in the interbank market.

Third, we then apply machine learning algorithms to investigate the network structure of Euro Area interbank market, i.e. calculating the local and global centrality measures and detecting the interbank borrowing and lending groups, that we call "communities". Formally, communities are groups of banks with the property that group members are strongly connected to each other in terms of interbank borrowing and lending than to others outside the group. We mapped out the EA interbank market network, and detected 13 communities in the interbank borrowing and lending market.[3] We find that French banks on average have the highest global

[3] Please see Figure 7A and 7B for the visualization of a complete network of large exposures for the EA interbank market. A detailed description of the interbank market is in Section 6.1.

and local importance in the EA interbank network, and have higher volume of interbank borrowing and lending across countries. In contrast, German banks have a large number of direct connections which are mostly located in the same community but the connected neighbors are not the most globally important players in the network.

More crucially, we find evidence that the impact of trust on interbank participation relies on the network structure of interbank market. The existing literature has identified core-periphery structures in interbank networks for different countries (e.g. Cocco et al., 2009; Craig and Von Peter, 2014; Gabrieli and Georg, 2014), while very few papers have explored the communities of interbank borrowing and lending. In this study we find the effect of network structure is twofold. On one hand, though banks in a community on average have lower interbank borrowing on average, being in a community can itself mitigate the negative effect of lacking trust in obtaining interbank funding. This suggests that when trust is low, being connected to communities can be helpful in obtaining interbank borrowing. On the other hand, being located at a central position globally in the network makes a difference. The impact of trust is stronger for core banks than for periphery banks, both statistically and economically. This is consistent with the existing literature documenting that lack of trust in intermediary banks can spill over to affect their borrowers' access to interbank funding (Craig and Ma, 2019). For robustness, we explore the interbank network with total exposures as well as that with only non-securities contracts or with only short-term exposures, and find consistent results supporting that the effect of trust depends on the interbank network structure.

Finally, trust is not a proxy for other determinants, especially the key bank characteristics, for interbank market participation. For example, we find that banks with higher liquidity mismatch and risk tend to have higher demand for interbank borrowing during normal periods, whereas during crises, such banks have less access to the interbank market. This is consistent with the relationships allowing banks to access liquidity in the presence of market frictions, such as transactions and information costs. Based on the market discipline theory, participants of the unsecured interbank market have incentives to monitor their counterparties due to the lack of collateral to hedge counterparty risk. Hence, riskier banks are expected to be credit

rationed although they might have higher liquidity needs (Furfine, 2001; Ashcraft and Bleakley, 2006; King, 2008).

Our study contributes to the literature on the lending relationship in the interbank market in the following three ways. First, to the best of our knowledge, this is the first study to present significant differences in banks' usage of interbank market across countries. Afonso et al. (2013) show that there is substantial heterogeneity in the structure of the trading relationship in the US overnight interbank lending market. Some banks rely on spot transactions, while most form stable, concentrated borrowing relationships to hedge liquidity needs. These borrowers with concentrated interbank relationships can be almost completely insulated from exogenous shocks. Cocco et al. (2009) use a unique dataset on the Portuguese interbank market and show that the relationships are an important determinant of interbank market activities. Larger banks with more imbalance in their reserve deposits are more likely to borrow funds from other banks than are those with less imbalance. Bräuning and Fecht (2017) use German interbank payment data and support the view that established relationships matter for the availability of interbank credit and affect the reallocation of liquidity through the interbank market. Craig and Ma (2019) examine systemic risk in the interbank market using the evidence from Germany and show that the shocks to intermediary banks in the financial crisis can spill over to the activities of the periphery banks. Das et al. (2019) use hand-collected data on correspondent relationships for all US banks to estimate the systemic risks. However, none of these studies utilizes cross-country interbank market data or documents differences in interbank market usage across countries. An important question is what determines interbank market participation. Through using the compiled dataset of domestic banks from 96 countries and then investigating the structure of Euro Area's interbank market, we document that trust is an important determinant of interbank activities and its influence relies on the interbank network structure, i.e. the core versus periphery positions and the communities of borrowing and lending.

Second, we contribute to the literature on interbank liquidity during crisis periods. Freixas and Jorge (2008) and Bruche and Suarez (2010) argue that during crises, there might be a reduction in interbank lending due to increased borrowers' counterparty risk, while Caballero

and Krishnamurthy (2008), Acharya and Skeie (2011), and Allen et al. (2009) attribute it to lenders' liquidity hoarding. Afonso et al. (2011), using the US overnight interbank market around the time of the Lehman bankruptcy, show that counterparty credit risk plays a larger role than precautionary liquidity hoarding does. Acharya and Merrouche (2013), using a sample of large settlement banks in the UK, report that after the crisis of 2007–2008, liquidity demand was precautionary in nature in that it increased on days of high payment activity and for banks with greater credit risk. Moreover, Iyer and Peydro (2011), using the setting of the Indian banking system, find robust evidence that higher interbank exposure to failed banks leads to larger deposit withdrawals and the interbank linkages among surviving banks further propagate the shocks. Iyer et al. (2014), employing a Portuguese loan-level dataset, finds that banks that relied more on interbank borrowing before the crisis decreased their credit supply more than other banks did during the crisis.

Lastly, this study is related to a growing literature on networks. We explore the Euro Area interbank network and find French banks have the highest global importance in the network, while German banks have more interbank activities within the same community. Das et al. (2019) explore the network for all commercial banks U.S. banks during the Great Depression and use centrality measures to estimate the systemic risks. Using a similar dataset, Mitchener and Richardson (2019) find the interbank lending networks amplified the contraction in lending during the Great Depression. Brunetti et al. (2019) examine the interbank behavior during and after the 2008 financial crisis and document that during the crisis the correlation network based on publicly traded bank returns shows an increase in interconnectedness while the physical network based on interbank lending transactions highlights a marked decrease in interconnectedness. Other than literature on financial network, recent studies also explore different types of economic network using the recently developed network topologies. For example, Hochberg et al. (2007) examine the network of venture capital and find better-networked VC firms in terms of higher centrality experience significantly better fund performance. Ahern and Harford (2014) represent the economy as a network of industries connected through customer and supplier trade flows and show stronger product-market connections lead a great incidence of cross-industry mergers. Allen et al. (2019) examine the

equity ownership network using all the registered Chinese firms and show the network position matters for firm future growth.

The reminder of the paper is organized as follows. Section 2 presents the stylized facts on the significant differences in interbank activity across countries. Section 3 describes the data source, sample construction as well as the summary statistics of key variables. Section 4 discusses the identification and network strategies. Section 5 presents the regression analysis suing international bank-level evidence on interbank borrowing. In Section 6, we describe the network structure of Euro Area interbank market and investigate the role of interbank network structure in influencing the effect of trust. Section 7 concludes.

2. Stylized facts

This section provides a cross-country overview of interbank market activity. Figures 1A and 1B show the structure of bank assets and liabilities for five countries: the US, Japan, France, Germany, and the UK from 2000 to 2009.[4] On average, the ratio of interbank loans to total bank assets is 2.4% for the US during this period, followed by Japan with a ratio of 4.9% and the UK with a ratio of 13.2%. France and Germany have much higher interbank loan ratios of 28.7% and 22.5%, respectively. Regarding liabilities, US banks have the lowest ratio of interbank deposits, 2%, followed by Japan, with a ratio of 4.4%, and the UK, with a ratio of 9%. Again, France and Germany have much higher interbank deposit ratios, at 31.2% and 26.6%, respectively.

In terms of other bank assets and liabilities, France and Germany also tend to have the highest ratios of loans to deposits among the five countries, at 116.9% and 105.6%, respectively. The average ratio of loans to deposits for Japanese banks is 80.6%, the lowest among the five countries. In Japan, the ratio reflects a "balance-sheet recession" over the two decades, characterized by a change in household and company behavior toward paying down debt and increased savings, even as interest rates remain at record low levels. Consequently,

[4] Figure B1 and Figure B2 in Internet Appendix show the dynamic change of structure of bank assets and liabilities from 2000 to 2009.

the economy slowed down due to reduced household consumption and business investment (Koo, 2014).

However, Table 1 shows some changes in the level of interbank deposits since the 2007–2009 global financial crisis. In all the countries except Japan, we observe a decline in interbank deposits relative to bank assets. The decline started in the UK and the US in 2007, while in France and Germany, it started in 2008. By contrast, in Japan, bank deposits slightly increased, but the level remained relatively low compared to deposits held by banks in France or Germany. Interestingly, the decline in interbank loans was much lower, and in most countries, the levels of interbank loans to banks' total assets are comparable to those observed in the years prior to the crisis. An exception is the US, where interbank loans and deposits remain significantly lower than before the crisis.

TABLE 1

The observed decline in interbank deposits and lending can be explained by the increased counterparty credit risk during the crisis. Indeed, declining trust during the crisis among banks in the US, UK, and EU might explain why the level of interbank deposits in those countries or region declined following the global financial crisis. Germany and France still have lower levels of deposits, which might be the outcome of new regulations restricting government bailouts in the future.

The simultaneous changes in interbank deposits and lending confirm that banks tend to hold significant interbank exposure on both sides of the balance sheet. The observation is in line with Bluhm et al. (2016), who find that banks lend to other banks and borrow from other banks simultaneously, and do so persistently. The authors term this property interbank intermediation to distinguish it from the traditionally defined bank intermediation. Moreover, they show that this intermediation is derivative to the banks' client book – household and firms, which determine the build-up of interbank books.

Figure 2 presents the interbank loans and deposits to total assets for domestic banks across the EU member countries in 2016, showing significant differences in interbank market activity by country. Among the EU member countries, Germany has a relatively large interbank market, where the average interbank loans and deposits amount to 11.4% and 13.5% of total assets in

2016, respectively. In contrast, interbank loans in Finland amounted to 0.7% of total assets, while interbank deposits amounted to 0.02% of total assets in Estonia in 2016. The average interbank loans and deposits for all EU banks remained strongly balanced and reached 5.7% of total assets.

FIGURE 2

The unbalanced structure of the balance sheet of the banks in some EU member countries might be due to foreign banks' activities. Figure 3 shows the interbank loans and assets of domestic and foreign subsidiaries and branches, and the share of foreign ownership in each country. After including the interbank activities of foreign banks, the interbank exposure on both sides of the balance sheet among the member countries is more balanced. However, Luxemburg and Malta are exceptions. Both countries are financial centers and with relatively high foreign ownership. When we account for the interbank activity of domestic and foreign banks, Luxemburg has the largest interbank market among the EU member countries. In 2016, the interbank loans and deposits in Luxemburg amount to 30.6% and 26.6% of total assets, respectively.

FIGURE 3

Lastly, Figure 4 shows the share of the total amount owed to credit institutions over total assets for domestic banks in the EU for 2007 to 2016. The data confirms the observation in Table 1 that interbank loans and deposits are not stable. In almost all countries, the amount owned to credit institutions declined over the period, which we attribute to the financial crisis of 2007-2008 and the Euro crisis of 2009. In the EU, the amount owned to all domestic credit institution over total assets declined from 15.5% in 2007 to 5.3% in 2016. During this period, only Romania, Finland, and Cyprus have higher borrowed amounts in 2016 than in 2007.

FIGURE 4

Overall, the data shows large variations in interbank activity, even among relatively homogenous countries, such as EU member states. However, across member countries, interbank exposure remained simultaneous on both sides of banks' balance sheets. Interbank deposits and loans were almost balanced for all EU banks. Moreover, we find a relatively large

variation in interbank activity across time. Existing literature rarely examines these two facts, which provides the motivation for our study.

3. Data and summary statistics

3.1 Sample construction

We compile two datasets for analyses in this study. The first is for banks around the globe, with interbank borrowing information from banks' balance sheets. To investigate how the network structure of interbank market affects the role of trust, we compile the second dataset for banks in Euro area, with the interbank bilateral exposure information from the European Central Bank for supervisory purposes.

3.1.1 Domestic interbank market participation around the globe

The first dataset is constructed as following. We obtain financial data on commercial, cooperative, and savings banks from the Bankscope database. Our sample period is 1995 to 2015, but the panel is unbalanced, as we do not have data for all years for each bank. Our sample comprises only banks that operate as independent companies or with single locations, as multinational banks use internal capital markets to fund and support their activities across countries (De Haas and Van Lelyveld, 2010). We also exclude foreign banks in our study since their activities may be highly affected by home countries' institutions. Foreign subsidiaries' interbank deposit decisions are likely to be determined more by the current policy of the multinational bank than by countries' institutional factors (See, Allen et al., 2013). Additionally, Adams-Kane et al. (2017) show that foreign bank activities are strongly influenced by the current home country's economic conditions. Thus, we decide to exclude all the foreign-owned banks, as their activities might be highly affected by the home countries' situation.

Therefore, we select for our sample only domestic-owned banks operating domestically. We classify a bank as domestic owned when 50% or more of its shares are held by domestic entities. In order to establish bank ownership, we create a dataset on the evolution of ownership for the period 1995–2015. This dataset builds on the data compiled by Claessens and Van

Horen (2014), which comprises only about one-third of our sample. This process allows us to have a sample of 11,557 domestic commercial banks, savings banks, and cooperative banks from 166 countries. Then we drop all the countries that have less than five operating banks from our sample, thereby reducing the number of banks in the sample by 1.3%. The final sample contains 11,412 domestic banks from more than 96 countries.[5]

The World Bank's Global Finance Database is used for information on country-level variables on financial system development (private credit to GDP) to measure the development of the banking system. Country-level variables on governance and regulation are from the Worldwide Governance Indicator (WGI) database constructed by Kaufmann et al. (2010). The database contains measures of legal enforcement, regulation quality, government effectiveness, and political stability for more than 200 countries. The information on countries' legal origin is from Djankov et al. (2007), which we update using mainly the CIA Factbook. The information on the years of systemic banking crisis is from Laeven and Valencia's (2013) database. They identify 147 crises in 115 countries over the period 1973–2011, and we update the database for the years until 2015.

We merge the abovementioned datasets. The bank's financial data in year *t* are matched with the country-level variables, such as financial structure and regulation, in year *t-1*. We end up with 74,572 bank-year observations. Additional information on the definitions and sources of variables are in Appendix Table A1.

3.1.2 Network structure of Euro Area banks

Our second dataset on bilateral interbank exposure comes from the ECB's confidential large exposures data. The large exposure regime, introduced in the EU in 2014, requires banks to report to prudential authorities detailed information about their largest exposures. An

[5] We classify a bank as domestically owned when 50% or more of its shares are held by domestic entities. As Claessens and Van Horen ownership database does not cover all the banks, we update the missing information on bank ownership using hand-collected information from various sources. The information sources used to build the dataset comprise primary *Bankscope*, supplemented by annual reports and national supervisory publications. For the sample distribution by country, please see Internet Appendix Table B1.

exposure to a single client or a connected group of clients is considered to be a large exposure when, before applying credit mitigations and exemptions, it is 10% or more of an institution's eligible capital. In addition, institutions are also required to report large exposure information for exposures with a value above or equal to EUR 300 million. Therefore, to date this dataset captures more than 50% of Euro area credit institutions' exposures. For the goal of studying the interbank network, the large exposures sample captures 90% of the EA banks' risk weighted assets vis-à-vis credit institutions (Covi, Gorpe and Kok, 2019; Covi, Montagna and Torri, 2019). Note that this data captures not only almost all borrowing and lending of EA banks among themselves, but also borrowing of non-EA banks from EA banks. For example, in the fourth quarter of 2018, the large exposures sample covers borrowing and lending among 1,362 banks (793 EA banks and 569 non-EA banks).

We then match the quarterly large exposures data over the fourth quarter of 2014 to the first quarter of 2019 with banks' financial information from BankFocus.[6] We also match with the country variables from World Governance Indicators (WGI) as well as the Global Finance Database for financial structure. We end up with a sample with interbank network structure information from the fourth quarter of 2014 to the end of 2017 for the regression analyses.

3.2 Variables and descriptive statistics

3.2.1 Interbank deposits and bank-level control variables

Table 1 presents large differences across countries in interbank deposits as well as interbank lending. We decide to investigate only interbank deposits for domestic banks around the globe as these data enable us to identify banks that take the deposits, but not the source (i.e., domestic or foreign). By contrast, in the case of interbank lending, we know the identities of banks that lend to other banks, but we do not know whether the bank is located in the same country or abroad, from the balance sheet data. We hypothesize that trust in the country's

[6] Since Bankscope is discontinued since 2015, we use banks' financial information from BankFocus to match with large exposures data for the period of 2014 to 2018.

financial system and the bank's counterparties are determinants of the differences in the interbank market across countries. Hence, our main dependent variable, *Interbank borrowing*, is measured as deposits and borrowing from banks scaled by total asset in year *t.*[7]

TABLE 1

Panel A of Table 2 provides detailed summary statistics for the dependent variable and the bank-level control variables for the panel of domestic banks around the globe. We winsorize the bank variables at 1% and 99%. The dependent variable *Interbank borrowing* ranges from 0 to 1, with a mean value of 0.08 and standard deviation of 0.11. The mean value of interbank borrowing averaged by country for our sample is slightly higher at 0.11, indicating that more banks are located in countries with lower levels of interbank borrowing.

We consider an assortment of bank characteristics. The ratio of loans to deposits (*LtD*) shows a large variation among the banks in the sample, yet the mean value indicates that in the average bank, deposits exceed loans, and consequently, these banks do not need to borrow in the interbank market. Thus, we can assume that the average bank locates its surplus funds either in the interbank market or in securities, mainly government bonds. Securities provide liquidity insurance, as they can be used as collateral in the interbank market, which enables banks to pool liquidity and settle unexpected transaction flows resulting from distributional shocks without holding cash. Hence, a high ratio of total securities to total assets (*Securities*) might indicate financial stability.

Similarly, banks with a solid capital base (*Equity*) and profitability (*ROA*) should signal stability and thus, be positively related to interbank borrowing. Furfine (2001) reports that borrowing banks with higher profitability and capital ratios pay lower interest rates in the interbank market. He also finds that bank size is an important determinant of transaction interest rates of interbank market participation. One explanation is that larger banks are more likely to be more creditworthy, because they are subject to too-big-to fail policies. *Banksize* is defined as the natural logarithm of bank total assets.

[7] Throughout the paper, we use the terms "interbank borrowing" and "interbank deposits" interchangeably, yet it should be underlined that interbank borrowing include both deposits and loans.

Panel B of Table 2 presents the differences in bank characteristics in the two group countries, which are divided based on their systemic banking crisis experience in the past. We classify a crisis as "long" if its duration was 5 years or more. On the other hand, a crisis is defined as "short" if its duration was less than 5 years. Next, we employ one-to-one propensity score matching based on a country's financial structure to define the "short" group of banks.

TABLE 2

The comparative statistics show that banks in countries that have experienced longer periods of banking crises tend to have significantly lower levels of interbank borrowings, which is in line with our expectations. The difference is statistically significant at the 1% level. The results show that banks in countries with longer crisis have significantly lower liquidity mismatch measured by *LtD*. Moreover, banks with longer crises have higher equity ratios, meaning that banks in those countries choose to have more conservative policies. Consequently, the results indicate that there are significant differences in banks' structure between countries with different histories of bank crisis.

3.2.2 Trust in the interbank market

In the last two decades, the economic literature has recognized that trust has a positive effect on economic development (Knack and Keefer, 1997) and financial development (Guiso et al., 2004; 2008). However, the concept of trust has received interest in the finance literature only recently. Most recent research has concentrated on relationship lending, which is not surprising, considering that the word "credit" originates from the Latin creditum, which means something entrusted to another; while in Middle French, "credit" means to believe, to trust, and to provide credit.

Various studies explore the role of trust in financial intermediation in recent years (e.g. Duarte et al., 2012; Hasan et al., 2017; Levine et al., 2018). Harhoff and Korting (1998), however, document that trust in the bank–firm relationship is complex and cannot be explained by other variables as duration of the relationship or the extent of competition (lenders). A popular proxy for trust in the literature is the World Values Survey, yet Glaeser et al. (2000) document that standard survey questions do not appear to measure trust, by arguing that

answers to the survey questions are more closely related to the trustworthiness of the respondents than to their propensity to trust others. More importantly, in our study, we are interested not in individuals' perceptions, but rather in the trust of banks in the interbank market participants within a country. Trust in individual people differs significantly from the trust of an organization in the market.

In our study, we define trust as a bank's belief in its peers' honesty and good-faith commitments within the country's interbank market. Our major two proxies for trust are directly related to banking system stability, *Crisis length* and *Bank failures*, as we consider that a long banking crisis as well a significant number of bank failures are traumatic experiences for the banking sector and consequently, for the interbank market. The first proxy, *Crisis length,* is defined as the length (number of years) of banking crises in the country till year *t*, over the period 1970 to 2015. Following Laeven and Valencia (2013), we define a systemic banking crisis as producing significant signs of financial distress in the banking sector and triggering significant policy interventions to assist or intervene. The starting year of the systemic banking crisis is that when both conditions are met. Meanwhile, the end of the crisis is defined as the year before both real GDP growth and real credit growth are positive for at least 2 consecutive years.[8] In our study, we focus on those crises that result in output loss of more than 10% of GDP. We assume that large systemic banking crises might lead to a decline of trust in the banking sector, including the interbank market. After merging the banking crisis database with the bank-level datasets, we are able to identify 314 systemic banking crises across countries.

Figure 5 shows the distribution of the number of countries with different levels of banking crisis length over the whole sample period from 1970 to 2015. In the sample, 22 countries have

[8] In all cases, however, the duration of the crisis is truncated after 5 years, starting from the 1st year of the crisis. As a result of the truncation in some of the countries, the global financial crisis of 2007–2009 was classified as finished, yet the countries did not in fact meet the criteria for ending the crisis by 2015. We keep the methodology of Laeven and Valencia (2013), as in our opinion, the truncation of the duration of the crisis does not affect our results.

never experienced a banking crisis, 27 countries had 1 to 3 years of banking crises, 31 countries had 4 to 6 years of crises, and 11 countries experienced more than 7 years of crises. Argentina and Ecuador are the two extreme countries that experienced a systemic banking crisis, which persisted for 10 years. The length (years) of banking crises allows us to consider both the frequency and severity of crises.

In addition, we set crisis windows spanning the 5 years of the banking crisis. The banking crisis window is proxied by the variable *Crisis*, which takes the value 1 in the year when the banking crisis became systemic, following the definition of Laeven and Valencia (2013), and 0 otherwise. The final year of the banking crisis is the year before both real GDP growth and real credit growth are positive for at least 2 consecutive years.

FIGURE 5

The second proxy, *Bank failure*, is defined as the standardized value of total assets of failed banks till year *t*, over the period 1970 to 2015. We use the status of a bank to identify whether it has severe financial problems. If a bank is marked in the Bankscope database as "bankrupt," "active (receivership)," or "in liquidation," then we treat it as a bank failure. How to deal with insolvent banks, whose numbers vary across countries significantly, is a political decision. We presume that the methods used to resolve bank failures can strongly determine trust in counterparties and the financial system.

The distinctive differences in resolution of banking crises across countries shows the outcome of the savings and loan crisis (S&L) in the US in the 1980s and 1990s and the banking crisis in Switzerland in 1991–1996. In both cases, the banking crisis affected mainly regional banks and was related to real estate booms in earlier years. As a result of the S&L crisis, US federal agencies liquidated 1,043 institutions and the total direct costs attributable to the closing of insolvent thrift institutions during 1986–1995 amounted to USD 145.7 billion (Curry and Shibut, 2000), which was around 2.5% of US GDP in 1990. In Switzerland, banks incurred estimated losses of around CHF 42 billion, which was more than 16% of Swiss GDP in 1990, yet only a single bank had to be liquidated (Westernhagen et al., 2004). In both cases, however,

the number of regional banks (thrift banks) was reduced by more than 50% at the end of the banking crisis.

In the European Union (EU) too, the number of bank failures remained relatively small in comparison to the US during the global financial crisis of 2007–2009. Nevertheless, based on the US experience, the 19 Eurozone countries introduced a new institution, the Single Resolution Board, in 2016, to deal in a unified way with failing institutions in the EU. Therefore, how a government deals with insolvent banks strongly determines trust within the banking sector, as bank failures are long-lasting traumatic experiences within the banking sector.

For robustness, we also use a third proxy, *Bank Z-score*, which measures the bankruptcy risk for individual banks. We calculate the Z-score as the ratio of a bank's leverage (capital over assets) and the mean of its ROA to the volatility of its ROA deduced from the probability that the bank's losses exceed its capital. The measure is often applied in the literature to measure the individual probability of default of banks (Laeven and Levine, 2009) as well to measure the banking system stability (Lee and Hsieh, 2014).

3.2.3 Legal origins, enforcement, and governance

The literature has shown that legal institutions and enforcement might influence the development of the financial system. Levine (1998) finds that banks are better developed in countries that protect creditors and enforce contracts effectively, which is one important feature of German-based legal systems. Countries with German-based legal systems tend to have better-developed banks. Thus, he argues that the legal system materially influences banking development.

We control for legal origins using the dummy variable *Common law*, which takes the value 1 if the country has a common law legal origin, and 0 otherwise. Panel A of Table 2 shows that the sample mean for the variable is 0.35, indicating that more banks are located in civil law countries in our sample.

Levine (1998) argues that enforcement of legal codes is as important as legal regulations themselves. We control for contract enforcement using the variable *Rule of law*. The variable is an estimated index on the extent to which agents have confidence in and abide by the rules of society, and in particular the quality of contract enforcement, property rights, and the courts. The index was developed first by Kaulfman et al. (1999) and then updated every year (Kaulfman et al., 2010). The original index ranges from -2.5 (weak governance) to 2.5 (strong governance). In our sample, the index ranges from -1.89 to 2.12, with a sample mean of 1.27.

We use two proxies to control for the quality of the government, country regulations, and their enforcement. The first proxy is the variable *Reg. quality*, which reflects the ability of the government to formulate and implement sound policies and regulations that permit and promote private sector development. The original index ranged from -2.5 (weak governance) to 2.5 (strong governance), whereas in our sample, it ranges from -2.15 to 2.25 with a sample mean of 1.16. The second proxy is the variable *Gov. effect*, which represents the quality of public services, the degree of its independence from political pressure, the quality of policy formulation and implementation, and the credibility of the government's commitment to such policies. The original index was also standardized from -2.5 (weak governance) to 2.5 (strong governance). For the countries in our sample, the minimum value is -1.71 and the maximum value is 2.36, with a sample mean of 1.31. The mean values of the two governance indicators indicate that more banks are located in countries with stronger legal enforcement and better governance. The summary statistics also show fairly large variations in the institutional development of countries in the sample.

3.2.4 Other country characteristics

The structure and development of a country's financial system might determine the functioning of the financial intermediaries and consequently, the interbank market. We use three variables to capture the characteristics of a country's financial system. First, we use *Private credit*, defined as the ratio of private credit by deposit money of banks to the country's GDP, to measure the development of the banking system. Private credit excludes credit to the public sector and cross claims of one group of intermediaries on another. Consequently, private

credit is a good measure of the amount of savings channeled through intermediaries to private borrowers. Second, we control for the size of central bank assets (*Central Bank*), following Demirgüç-Kunt and Huizinga (2000), which illustrate that in developing countries, the central bank plays a relatively large role in credit provision. Third, we also control for stock market development using the variable *Market cap*, defined as the ratio of stock market capitalization to the country's GDP. Lastly, we also consider the power of banks in a country by means of the combined market share using the assets of the three largest banks (*Concentration*). Existing evidence shows that concentrated banking systems are more stable and less likely to have crises (Beck et al., 2001; Schaeck et al., 2009) Hence, we would expect that banking sector concentration will be positively related to the size of the country's' interbank market.

4. Methodology and identification

4.1 Identification

Interbank markets are informal markets that enable banks to manage, pool, and redistribute their funds, and thereby provide lending and deposit facilities more efficiently. The amount borrowed and interest rate charged on interbank transactions reflects, in part, the credit risk of the borrowing institution (Broecker, 1990). This, however, does not explain the significant difference of the use of the interbank market across countries. We consider that an important factor explaining the existing differences in the interbank market is the level of trust of banks in a country's market and its peers. To test this hypothesis, we estimate the following baseline model, controlling for bank- and country-specific characteristics:

$$Interbank\ borrowing_{i,j,t} = \beta_0 + \beta_1 Bank_{i,j,t} + \beta_2 Country_{\ j,t} + \beta_3 Trust_{j,t} + \beta_4 Y_{i,j,t} + \varepsilon_{i,j,t} \qquad (1)$$

where the indexes *i*, *j*, and *t* represent bank, country, and time, respectively. The vector of bank-specific variables, $Bank_{i,j,t}$, characterizes bank performance and risk. In particular, we include proxies for funding structure, securities, equity performance, and bank size. The vector of country-specific variables, $Country_{j,t}$, characterizes the countries' legal system, institutional

development, and structure of financial system. The relationship between interbank borrowing and our proxies for trust, $Trust_{i,j,t,}$ is allowed to vary across countries and time. Furthermore, we include year fixed effects, $Y_{i,j,t,}$. We do not control for country fixed effects, as some country-specific variables are time invariant, such as legal origins, or have quite low variance across time.

4.2 Network analysis methodology

Network analysis methodology, built on graph theory, has been increasingly exploited in the finance literature. Two central features of network structure are centrality and community. Centrality has been widely used (e.g. Hochberg et al., 2007; Larcher et al., 2013; Engelberg et al., 2013), reflecting both local and global importance, i.e. how each entity (node in the network) is connected to others, and further how "important" the position of each entity is in the entire network. In graph theory, generally a network is described by a square "adjacency" matrix, the elements of which reflect the strength of the connections among each entity (node) in the network. In our setting, the interbank network is a directed and weighted network. Therefore, the matrix representing the interbank network is asymmetric, indicating the flow of borrowing and lending. The nodes in the network are banks borrowing through interbank market, and the edges, are weighted by the borrowing volume. Figure 7A visualizes the interbank borrowing and lending network for Euro area banks.

In this study, we mainly use *Degree* centrality, *Eigenvector* centrality as well as *PageRank* to measure the importance of the position and the degree of intermediation in the interbank network. *Degree* centrality (both in-degree and out-degree) captures the direct connections and therefore the local importance, whereas *Eigenvector* centrality and *PageRank* extend beyond the direct connections and show the global influence in the entire network. *Eigenvector* centrality is defined recursively as the importance (centrality) of a node relies on the importance (centrality) of its direct neighbors. *PageRank* is a variant of *Eigenvector*, resulted

from an algorithm based on webgraph, and can reflect not only the number of direct links, but also the link propensity as well as the centrality of the neighbors.[9]

Community membership is related to centrality, but a fundamentally different concept (see, e.g. Bubna et al., 2019). A community is essentially a group of nodes that have strong connections to each other. To do community detection, we use *Modularity*, which reflects whether the linkage between two banks through interbank borrowing is strong or not. Through optimizing the *Modularity* we identify banks into different communities (clusters). We use communities and clusters interchangeably throughout the paper. As an illustration, Figure 7B plots the interbank network groups by communities presented by different colours.

5. International evidence on interbank borrowing

5.1 Baseline results

The results in Table 3 document that bank and country characteristics as well trust are important in explaining the level of interbank borrowing across countries. In columns (1) to (3), we use *Crisis length* as a proxy for the trust in the banking system, whereas in column (4) to (6), we use *Bank failures* instead. In all the specifications, the coefficients for the variables *Crisis length* and *Bank failures* are negative and statistically significant at the 1% level. Both variables confirm that higher trust in the interbank market can improve the usage of the interbank market. The coefficients of *Crisis length* suggest that one more year of crisis experienced in the history may reduce the interbank borrowing size by 4.3% (0.00336/0.0775). The coefficients of *Bank failure* also indicate that more bank failures in the past would reduce the interbank market size. In terms of economic magnitude, 1% increase in *Bank failure*, defined as the standardized value of total assets of failed banks,is associated with 2.4% (0.00189/0.0775) decrease in interbank borrowing size.

[9] For the formal definition of centrality, please see, e.g. Jackson (2008), Allen et al. (2019), and Brunetti et al. (2019).

The bank-specific variables are in line with our predictions; only the coefficient for bank profitability (ROA) is not significant in all the regressions. Meanwhile, the coefficients for the remaining bank-specific variables, other than ROA, are all statistically significant at the 1% level. The coefficient for *Size* is positive in all the regressions. This is in line with the findings of Cocco et al. (2009), who argue that large banks are more likely to be net borrowers whereas smaller banks tend to be net lenders in the interbank market. As expected, banks with funding needs, or higher loans-to-deposit ratios, are more likely to borrow in the interbank market. Surprisingly, however, the equity ratio and the coefficient for profitability is negative in all the regressions, meaning that banks that obtain funding in the interbank market are more likely to have lower capitalization, which does not imply higher risk, taking into account that the coefficient for *Securities* is positively related to interbank borrowing. The funding strategy of the banks might explain the lower profitability, as interbank funding is relatively costlier than non-financial deposits are, while securities provide lower interest income than loans do.

The country-specific variables indicate that both the institutional factors and financial structure are important determinants of interbank market size. The coefficient for *Common law* is significant and positively related to interbank market borrowing. One explanation for this result is that common law countries provide better institutional protection for interbank market participants. Indeed, in all the specifications, the coefficients for *Rule of law, Reg. quality* and *Gov. effect* are positive and statistically significantly at the 1% level. Thus, the results indicate that institutional development is an important determinant of interbank market development.

Another explanation for this result could be that common law countries tend to have better developed financial systems (La Porta et al., 1998). The results, however, indicate that interbank market usage is larger only in countries with strong bank-based financial systems. The coefficient for *Private credit* is positive and significant in all the specifications. In terms of economic impact, taking column (1) as an example, 1% increase in private credit to GDP ratio is associated with 12.7% (0.00984/0.0775) more volume in the interbank market. By contrast, we find that central bank assets and market capitalization are negatively related to interbank borrowing and the coefficients are statistically significant. The results indicate that

in countries where banks have a larger role in financial intermediation than central banks or capital markets do interbank market volume tends to be higher. Moreover, Beck et al. (2013) find that an increase in competition has a larger impact on banks' risk-taking incentives in countries with better developed stock exchanges. Considering that the coefficient for concentration is positively and significantly related to the interbank market at the 1% level in all the specifications, the analysis again confirms the importance of banking sector stability in explaining the levels of interbank market volume.

TABLE 3

We repeat the regressions using Bank Z-score as another proxy for the trust in the banking system. In column (1) to (3) we run the regressions using the full sample while in column (4) to (6) we exclude U.S. banks. Table 4 reports the results. Consistently, we find that the coefficient of *Bank z-score* is negative in all the regressions and is statistically significant in all the specifications at the 1% level, confirming that trust in the stability of the banking sector is an important factor explaining the levels of interbank market usage across countries. The coefficient for the bank-specific variables and country-specific variables do not change much after employing a different proxy for trust and mostly remain significant.

TABLE 4

5.2 The role of trust in interbank participation

The trade-off between counterparty risk and liquidity hoarding suggests that trust plays a key role in the unsecured interbank market. A systemic banking crisis with a number of bank failures could be a negative exogenous shock to future trust in the interbank market. The results in Tables 3 and 4 show that if a bank is located in a country with higher risk of bank failure and higher amount of total assets of failed banks or longer periods of banking crises in the past, then it will borrow less on average in the interbank market. In addition, the usage of the interbank market might be strongly determined by the structure of the financial system. Claessens et al. (2001) document that recessions and financial disruptions in emerging markets are often more costly than in developed countries, and it takes more time for emerging

economies to recover. They attribute this difference to the fact that emerging countries have less developed financial systems. Meanwhile, Demirgüç-Kunt and Levine (1999) observe the tendency for countries' financial systems to become more market-oriented as they become richer. Therefore, we can assume that in countries with bank-based financial systems, which are often emerging economies, the banking crisis has on average a stronger negative effect on the usage of the interbank market. Consequently, the structure of the financial system, especially the role of banks in intermediation, can determine our results.

We use the difference-in-difference estimation technique to isolate this possibility and further explore the causality of bank failures and banking crises on the development pattern of the interbank market, controlling for the structure of the financial system. As traumatic experience has a strong impact on trust (Alesina and La Ferrara, 2002), we define a treatment group and a control group of banks based on the total duration of all banking crises in the past. In the regression, the variable *Treated* equals 1 if the bank is located in a country with a history of past banking crisis longer than (or equal to) 5 years in total, and 0 otherwise. Next, we employ the propensity score-matching algorithm without replacement based on the structure and development of the financial system, *Private credit* and *Mkt. cap.*, to define the control group of banks. Table 5 presents the regression results on the effect of banking crises on interbank market size using the matched sample. In all the specifications, the coefficient of *Treated* is negative and significant at the 1% level. Furthermore, the results are economically important, as they show that in column (1), *ceteris paribus*, banks can reduce interbank borrowing by up to 22.8% (0.0177/0.0775) if they are located in a treated country than in a control country.

TABLE 5

5.3 The mitigating role of legal and regulatory institutions

Numerous studies suggest that legal and institutional difference shape both the price term and the non-price terms of bank loans across the world (See, e.g. Qian and Strahan, 2007). Not surprisingly, we also find that institutions are an important factor in explaining borrowing in

interbank markets. Indeed, the coefficients for legal origin and institutions were statistically significant at least at the 1% level in all the regressions. Qian and Strahan (2007) argue that improving countries' institutions might improve financial outcomes by reducing the risks associated with lending. Based on their argument, we can expect better institutions to mitigate the lack of trust in a country's interbank market following shocks from banking crises. We test this assumption by introducing an interaction term between banking crisis window and governance indicators in the regressions.

Table 6 reports the results for the crisis window and the interaction term. First, we find that a systemic banking crisis negatively affects interbank borrowing. The coefficient for the crisis window variable, *Crisis*, has statistically significant negative signs in all the regressions at the 1% level. We find that a current systemic banking crisis has a much larger negative effect on interbank market transactions than past experience does, as the coefficient for the crisis windows is significantly larger than that for the length of past banking crisis. For example, the coefficient in column (1) suggest that during a banking crisis, the interbank borrowing can drop by 35.1% (0.0272/0.0775) on average. Consequently, we find strong evidence that the interbank market is likely to malfunction during a financial crisis. Acharya and Skeike (2011) explain the reduced volumes or extreme levels of rates for interbank loans during a crisis by banks' precautionary demand for liquidity. They argue that banks hoard liquidity and decrease term lending, which is determined by its own risk that it will be unable to roll over debt that matures before the term of the interbank loan. Similarly, Acharya and Merrouche (2013) show that banks, especially weaker ones, hoarded liquidity in response to the funding risk during the global financial crisis of 2007. Bräuning and Fecht (2017), on the other hand, argue that increased counterparty credit risk negatively affected interbank liquidity during the crisis of 2007.

TABLE 6

However, our results show that the negative effect of the global financial crisis on interbank market malfunctioning might depend on countries' institutional frameworks. In all the regressions, the interaction terms between governance indicators and *Crisis* have significant

and positive coefficients, indicating that in countries with better legal enforcement, regulation quality, or stronger government effectiveness,the marginal negative impact of a banking crisis on interbank borrowing would be mitigated significantly. These results are consistent with those of Qian and Strahan (2007), who find that institutional factors enhance loan availability. Our results show that institutional factors are important for the functioning of the interbank market, including crisis periods. There are at least two possible explanations for why those institutional factors are important during a crisis period. First, it might be easier for banks to overcome the increased counterparty credit risk in the interbank market during a crisis with high regulation quality and strong enforcement. Second, stronger government effectiveness is likely to be related to a well-functioning central bank, which might be willing to intervene in the interbank market during a crisis period. Allen et al. (2009) present a model showing that a central bank can successfully intervene to fix malfunctioning interbank markets.

5.4 Robustness analysis

Lastly, we performed several additional tests to gauge the robustness of our results. First, we exclude the US banks from our sample as they account for 40.5% (4,620 banks out of 11,412) observations. Hence, the results of the study may be biased by the overrepresentation of the US banks in the sample. After excluding US banks, we have in total 6,792 banks over 95 countries. Table A.3 and Table 4 columns (4) to (6) reports the results, which are highly consistent with those suggested with the main results in Table 3 and columns (1)-(3) in Table 4. The results may also be influenced by major banks located in global financial centers. There has been some evidence showing that the interbank market is dominated by the offices of major banks located in the principal financial centers around the world (BIS, 1983). For the international interbank market, the main criteria for participation are that the borrowing bank establishes itself as creditworthy in the eyes of other banks and further it is not constrained by regulatory obstacles, such as exchanges controls or supervisory limits. We decided, therefore, to exclude banks from US, UK, Singapore, and Hong Kong from the sample. We find that excluding the banks from those countries does not change our main results, We present the results in the Internet Appendix Table B2 for brevity.

Besides their need for working balances, banks' demand for interbank funds is driven by the required reserves that they have to hold at the central bank. Links between the overnight interbank market and the market for bank reserves are strongly associated with reserve requirement arrangements. Gray (2011) shows that the reserve requirements as well the basis of its calculations varies strongly across the countries, which in turn could influence our results. We decided, henceforth, to rerun the regressions using only banks from the euro area, which are subject to the same central bank policy. We use both the 11 original Euro zone countries and the 19 countries that are Eurozone members nowadays. Column 1 and 2 Table 7 shows the results for the two subsamples, respectively. We find that the coefficients of the proxy for trust are negatively correlated and statistically significant in the specifications, meaning that our results are not influenced by central bank policies.

TABLE 7

Cocco et al. (2009) documents that bank size is an important determinant of interbank market interest rates, and of lending relationships. On average, large (small) banks tend to be net borrowers (lenders) in the market. Iori et al. (2008) document that not all banks actively manage their minimum reserves, and smaller banks tend to keep their reserve account at the required level constantly through the maintenance period. The existing results thus indicate that banks' size may be an important determinant of interbank lending and borrowing. Therefore, we further introduce a dummy variable, *Large*, defined as the one for the upper quartile and zero for the lower quartile based on the total bank assets, and interact it with the trust measure *Crisis length*. Column (3) in Table 7 show that large banks tend to borrow more from the interbank market, and the effect of trust is more pronounced for larger banks, with the coefficient of the interaction being significantly negative.

To further tackle the endogeneity concern, that the interbank borrowing might be influenced by other unobserved factors correlated to trust, we further employ instrumental variable (IV) analysis. The instruments we employ are the usage of deposit insurance scheme as well as the power of deposit insurance scheme in a given country. The data are collected

from Demirgic-Kunt et al. (2014).[10] The existence as well as the power of deposit insurance scheme in country *i* of year *t-1* is matched with the interbank borrowing of banks located in country *i* of year *t*. It satisfies the relevance condition that, countries with a larger number of banking crises and failures are more likely to introduce the safety net, i.e. the deposit insurance, so the trust can be restored. Demirgic-Kunt et al. (2014) document that fourteen countries introduced the explicit deposit insurance since 2008, and almost all countries with explicit deposit insurance that experienced a banking crisis increased the statutory coverage limit in their deposit insurance scheme. The exclusive condition is also very likely to be satisfied as the interbank borrowing (deposits) is based on credit, and not covered by the deposit insurance. Hence, the instruments will affect interbank borrowing only through trust rather than other unobserved factors. Table 9 reports the two-stage least-squares regression results. Column (1) and (2) use *ExDI* and column (3) and (4) use *DI power* as the instruments. The first-stage results show that both instruments are significantly and positively associated with the trust measure, *Crisis length*. The second-stage results confirm with our main results that lack of trust reduces interbank borrowing, at least at the 5% significance level. To sum up, the additional tests above further confirm the robustness of our results on the importance of trust on the activity of interbank market.

TABLE 8

6. The role of network structure: Euro Area interbank market

The existing literature has identified core-periphery structures in many different interbank networks (e.g. Cocco et al., 2009). Therefore, one concern would be that lack of trust in core banks, who act as interbank intermediaries, might have very different implications for how much the overall borrowing network declines (Craig and Ma, 2019). Therefore, in this section, we use the Euro area interbank market to explore how the network structure may affect the role of trust in determining interbank borrowing.

[10] For the details about this database, please see: https://www.imf.org/en/Publications/WP/Issues/2016/12/31/Deposit-Insurance-Database-41710

6.1 Describing the Euro Area interbank network

Figure 6 plots the EA interbank borrowing and lending network in 2018Q4. Figure 6A groups the banks by country, with the node color reflecting banks' home country. Node size represents the eigenvector centrality, therefore, how globally important the bank is in the entire EA interbank network. Edge color represents the country receiving the exposures. The algorithm of the layout is *Multigravity Force Atlas 2*. In Figure 6A, red nodes refer to German banks, and black nodes refer to French banks. In Figure 6B, we use different colors for communities detected using *Modularity*, with all the nodes positioned at the same places in the network as Figure 6A shows. We have detected 13 communities (Community 0 to 12) in the Euro area interbank network. Table 9 reports the joint distribution of country and community group. Germany has the largest number of banks (249 banks in total) in the network, with 82 percent of banks (218 banks) located in Community 3. At the same time, Community 3 is also dominant by German banks. Italian banks are mostly located in Community 6 (85 out of 103 banks in total). French banks are distributed across different communities, indicating that French banks have higher volumes of borrowing and lending across countries.

FIGURE 6A & 6B

TABLE 9

Table 10 presents the mean value of network centralities, cluster coefficients a well as average path length for each country over the fourth quarter of 2014 to the fourth quarter of 2018, sorted by the *Eigenvector* centrality. The statistics of the network measures show that in the Euro area interbank network, French banks on average have the highest both local and global importance, suggesting that the French interbank market is more dominated by intermediary banks. German banks have much lower *Eigenvector* centrality but still quite high values of *Degree* centrality, compared to Belgium and Ireland, which both ranked ahead of Germany in terms of *Eigenvector*. This suggests that German banks have strong direct connections but the connected neighbors are not globally important players in the interbank network. This is also consistent with the fact that German banks are mostly located in the same community (Community 3), as shown in Table 9. The cluster coefficients of bank nodes capture

how complete the neighborhood of a bank node is.[11] The mean value of cluster coefficients suggests that both German and Slovenian banks are the best connected within the communities, indicating a "small-world" effect, that banks are borrowing and lending more within communities. Longer average length suggests a lower degree of intermediation. Hence, its statistics show that Italy, Ireland and Netherland have the highest degree of intermediation on average in the interbank market.

TABLE 10

Figure 7 plots the quarterly change of the mean value of *Weighted in-degree* and *Eigenvector* centrality of the entire network from 2014 to 2019. The figure shows that on average Euro area banks are borrowing less from the interbank market since the 2nd quarter of 2017. The global importance in terms of Eigenvector also dropped in early 2017 but rebounded soon later.

FIGURE 7

6.2 Determinants of interbank market participation: the role of network structure

We then explore how the network structure affects the role of trust in determining interbank participation. First of all, instead of using interbank borrowing (deposits) from banks' balance sheet, we use interbank network centralities (*Log inwdeg*, *Log page rank* and *Log eigen*) to measure the interbank market participation, as the dependent variable in the regression specifications. For the measures of trust, we use the *Crisis length*, as well as *Failure ratio*, defined as the total assets of failed banks over total assets of the banking system in a given country till year *t*. We use the ratio of the failed assets, instead of the standardized value of failed assets, as here in the EA interbank network, we are considering not only the domestic, but also the cross-border borrowing and lending activities. Hence, *Failure ratio* can be a better

[11] For example, if every bank node in the neighbourhood of bank A is connected to every other node in the neighbourhood of bank A, then the neighbourhood of bank A is complete and will have a clustering coefficient of 1; if no bank nodes in the neighbourhood of bank A are connected, then the clustering coefficient is 0.

proxy for trust, especially for cross-border lenders. Table 11 reports the baseline regression results, for EA network. In column (1) to (3), we use the centrality measures calculated from the network of the total exposure, which includes not only the borrowing and lending between EA banks, but also nonEA banks' borrowing from EA banks, whereas in column (4) to (6) we use centrality measures calculated from the network of EA exposures, which covers only the borrowing and lending between EA banks. *Cluster* is defined as one if the cluster coefficient of a bank node is above median, or zero otherwise. The results show that *Crisis length* and *Failure ratio* both enter with negative signs, significantly in most of the specification, suggesting that lack of trust can reduce interbank activities, in terms of both interbank borrowing from the direct neighbors and global activities (borrowing and lending) in the interbank network. Being connected to a community is negatively associated with interbank participation, locally and globally, consistent with the "small world" effect of being in a community. In addition, larger banks tend to have higher centrality in the interbank network. The results are robust when we exclude the exposures from EA banks to nonEA banks.

TABLE 11

We then investigate how the core-periphery structure affects the interbank activities. Craig and Ma (2019) show that lack of trust in intermediary banks can spill over to affect their borrowers' access to interbank funding. Hence, trust would have different implications for core versus periphery banks. We use *Eigenvector* centrality to identify core and periphery positions in the network. *Central* is defined as one if the eigenvector centrality is in the upper quartile, or as zero if in the lower quartile. The dependent variable is *Log inwdeg*, which measures the interbank borrowing at the bank-level. We also consider both the network of total exposures and the network of exposures only between EA banks. To capture how the network structure affects the influence of trust, we interact the trust measures with *Central*. The results, reported in Table 12, show that the impact of trust is more significant for banks in core positions, with all the interactions entering with significant and negative coefficients. Again, banks located in a community are likely to have lower interbank borrowing, while those located at a core

position are likely to have higher interbank borrowing. Controlling for the average path length, as shown in column (2) and (4), does not affect the results.

TABLE 12

We then further examine how the network structure, in terms of clustering, would affect the role of trust. Again, we use centrality measures from the network of the total exposures as well as those from the network of EA exposures as dependent variables. To examine the effect of clustering, we introduce the interactions of trust measures and *Cluster*. Table 13 reports the results. Both trust measures enter with strong negative coefficients in all the specifications, confirming our main results that lack of trust reduces interbank participation. More importantly, being in a community tends to mitigate the negative effect of trust, suggested by the significant and positive coefficients of the interactions in all the columns. This indicates that when trust is low in the interbank market, being in a cluster might provide an additional source of funding due to community relationship.

TABLE 13

For robustness, we also exclude exposures of securities contracts as well as long-term (longer than 30 days) exposures from the network. Table 14 reports the results. We incorporate both interactions, trust with *Central*, and trust with *Cluster*, into the regressions. Table 14 reports the results. The interactions of trust and *Central* enter with strong negative coefficients, and the interaction of trust and *Cluster* enter with strong positive coefficients, for both networks. These confirm our finding that lack of trust may have stronger effect in core (intermediary) banks, while being in a community can provide additional interbank funding when trust is low.

TABLE 14

7. Conclusion

The interbank market is an informal market that enables banks to manage and redistribute their funds, and so provide financial intermediation more efficiently. The bilateral nature of the

interbank market does not differ across countries. We document however that banks engagement in the interbank market differs strongly across the countries. In this study, we investigate the explanations for those differences and find that trust in the banking sector and peers is an important factor explaining the differences in the interbank market activity across countries. More specifically, we show that if a bank is located in a country that has experienced longer banking crisis or more bank failures in the past, finance its activity to lesser extend using the interbank market.

Through mapping and investigating the Euro Area's interbank market using machine learning algorithms, we find the impact of trust relies on the network structure of the interbank market. The influence of network structure is twofold. First, being in a community can mitigate the negative effect of lacking trust in obtaining interbank funding. Second, the impact of trust is more significant for banks in core positions than those in periphery positions in the network, suggesting a spill-over effect for intermediary banks in transmitting risks. Our finding is robust when applying the network of total exposures, or the network of non-securities contracts, or the network of short-term exposures.

Lastly, we show that countries institutional factor such as legal enforcement and regulation quality play an important role in explaining the cross-country difference in interbank participation, and may mitigate the adverse impact of banking crises or bank's failures in the past. The results are consistent with the law and finance literature showing that a strong institutional framework enhance loan availability in unsecured markets as it provides better protection against bankruptcy. In line with the literature we also find that bank characteristics, especially bank's funding ratio and size, are important factors in explaining the level of banks activity in the interbank market. The results confirm that in an unsecured credit markets such as interbank markets, peer monitoring plays an important role.

Reference

Acharya, V., D. Gromb and T. Yorulmzer, 2012. Imperfect competition in the interbank market for liquidity as a rationale for central banking, *American Economic Journal: Macroeconomics* 4 (2): 184-217.

Acharya, V. and O. Merrouche, 2013. Precautionary Hoarding of Liquidity and Interbank Market: Evidence from the Subprime Crisis, *Review of Finance* 17: 107-160.

Acharya, V., and D. Skeie, 2011. A model of liquidity hoarding and term premia in interbank markets, *Journal of Monetary Economics* 58: 436-447.

Adams-Kane, J., J.A. Caballero, and J.J. Lim, 2017. Foreign bank behavior during financial crises. *Journal of Money, Credit and Banking*, 49(2-3): 351-392.

Ahern, K. and J. Harford, 2014. The Importance of Industry Links in Merger Waves, *Journal of Finance*, 69(2): 527-576.

Alesina, A. and E. La Ferrara, 2002. Who trusts others?. *Journal of Public Economics* 85(2): 207-234.

Allen, F., J. Cai, X. Gu, J. Qian, L. Zhao and W. Zhu, 2019. Ownership Network and Firm Growth: What Do Five Million Companies Tell About Chinese Economy. Imperial College London Working Paper.

Allen, F., E. Carletti, and D. Gale, 2009. Interbank Market Liquidity and Central Bank Intervention, *Journal of Monetary Economics* 56(5), 639-652.

Allen, F., X. Gu and O. Kowalewski, 2012. Financial Crisis, Structure and Reform, *Journal of Banking and Finance* 36: 2960–2973.

Allen, F., X. Gu and O. Kowalewski, 2013. *Corporate governance and intra-group transactions in European bank holding companies during the crisis*. In *Global banking, financial markets and crises*. Emerald Group Publishing Limited: 365-4.

Ashcraft, G. and H. Bleakley, 2006. On the Market Discipline of Informationally Opaque Firms: Evidence from Bank Borrowers in the Federal Funds Market, *Federal Reserve Bank of New York Staff Reports*, No. 257.

Afonso, G., A. Kovner and A. Schoar, 2011. Stressed, not Frozen, The Federal Funds Market in the Financial Crisis, *Journal of Finance* 66(4): 1109-1139.

Afonso, G., A. Kovner, and A. Schoar, 2013. Trading partners in the interbank market, *Staff Reports* 620, Federal Reserve Bank of New York.

Bank of International Settlements, 1983. *The International Interbank Market: A Descriptive Study*, Monetary and Economic Department, Basel.

Beck, T., Jonghe, O. D., and Schepens, G, 2013. Bank competition and stability: Cross-country heterogeneity. *Journal of Financial Intermediation*, 22(2), 218–244.

Beck, T., A. Demirgüç-Kunt, R. Levine and V. Maksimovic, 2001. *Financial Structure and Economic Development: Firm, Industry and Country Evidence*, in A. Demirgüç-Kunt and R. Leveine (eds.), *Financial Structure and Economic Growth: A Cross Country Comparison of Banks, Markets and Development*, New York: Oxford University Press.

Bernard, H. and J. Bisignano, 2000. Information, liquidity and risk in the international interbank market: implicit guarantees and private credit market failure, *BIS Working Paper* 86.

Bhattacharya, S. and D. Gale, 1987. *Preference Shocks, Liquidity and Central Bank Policy*, in W. Barnett and K. Singleton (eds.), *New Approaches to Monetary Economics*, Cambridge University Press, 69-88.

Bluhm, M., Georg, C., Krahnen, J., 2016. Interbank Intermediation. *Deutsche Bundesbank Discussion Paper* 16/2016.

Bräuning, F. and Fecht, F., 2017. Relationship lending in the interbank market and the price of liquidity. *Review of Finance* 21(1): 33-75.

Broecker, T., 1990. Credit-worthiness tests and interbank competition. *Econometrica: Journal of the Econometric Society* 58(2): 429-452.

Bruche, M. and J. Suarez, 2010. Deposit insurance and money market freezes. *Journal of Monetary Economics* 57(1): 45-61.

Brunetti, C., J. Harris, S. Mankad, and G. Michailidis, 2019. Interconnectedness in the Interbank Market. *Journal of Financial Economics*, forthcoming.

Bubna, A., S. Das, and N. Prabhala, 2019. Venture Capital Communities, *Journal of Financial and Quantitative Analysis*, fourthcoming.

Caballero, R. J. and A. Krishnamurthy, 2008. Collective risk management in a flight to quality episode, *Journal of Finance* 63(5): 2195-2230.

Claessens, S., A. Demirguc-Kunt, H. Huizinga, 2001. How does foreign entry affect domestic banking markets? *Journal of Banking and Finance* 25(5): 891-911.

Cocco, F., F. Gomes, and N. Martin, 2009. Lending relationships in the interbank market. *Journal of Financial Intermediation* 18: 24-48.

Claessens, S. and N. van Horen, 2014. Foreign banks: trends and impact. *Journal of Money, Credit and Banking* 46(1): 295-326.

Covi, G., M. Gorpe and C. Kok. 2019. CoMap: Mapping Contagion in the Euro Area Banking Sector. ECB Working Paper No. 2224.

Covi, G., M. Montagna and G. Torri, 2019. Economic Shocks and Contagion in the Euro Area Banking Sector: A New Micro-structural Approach. ECB Financial Stability Review, May:https://www.ecb.europa.eu/pub/financial-stability/fsr/special/html/ecb.fsrart201905_2~073bba7192.en.html#toc1.

Craig, B. and G. von Peter, 2014. Interbank Tiering and Money Center Banks, *Journal of Financial Intermediation*, 23(3): 322-347.

Craig, B. and Y. Ma, 2019. Intermediation in the Interbank Lending Market. Columbia Business School Working Paper.

Curry, T. and L. Shibut, 2000. The cost of the Savings and Loan crisis: Truth and consequences, *FDIC Banking Review* 13(2): 26-35.

Das, S., K. Mitchener and A. Vossmeyer, 2019. Systemic Risk and the Great Depression. Working Paper.

De Haas, R. and I. van Lelyveld, 2010. Internal capital markets and lending by multinational bank subsidiaries. *Journal of Financial Intermediation* 19(1): 1-25.

Demirgüç-Kunt, A. and R. Levine 1999. Bank-based and market-based financial systems: Cross-country comparisons. *IMF Policy Research Working Paper* 2143.

Demirgüç-Kunt, A and H. Huizinga, 2000. Financial structure and bank profitability. *World Bank* Policy Research Working Paper Series 2430

Demirgüç-Kunt, A, E. Kane and L. Laeven, 2014. Deposit Insurance Database. IMF Working Paper No. 14/118.

Djankov, S, C. Mcliesh and A. Shleifer, 2007. Private credit in 129 countries. *Journal of Financial Economics* 84: 299–329.

Duarte, J., S. Siegel and L. Young, 2012. Trust and credit: the role of appearance in peer-to-peer lending. *Review of Financial Studies* 25(8): 2455-2484.

Engelberg, J., P. Gao, and C. Parsons, 2013. The Value of a Rolodex: CEO Pay and Personal Networks, *Review of Financial Studies*, 26: 79-114.

Freixas, X. and J. Jorge, 2008. The role of interbank markets in monetary policy: A model with rationing. *Journal of Money, Credit and Banking* 40(6): 1151-1176.

Furfine, C., 2001. Banks as monitors of other banks: evidence from the overnight federal funds market. *Journal of Business* 72: 33-57.

Gabrieli, S. and C. Georg. 2014. A Network View on Interbank Market Freezes, Bundesbank Discussion Paper No. 44/2014.

Glaeser, E.L., D.I. Laibson, J.A. Scheinkman, and C.L. Soutter, 2000. Measuring trust. *Quarterly Journal of Economics* 115(3): 811-846.

Gray, S., 2011. Central bank balances and reserve requirements. *IMF Working Paper* No. 11-36.

Guiso, L., Sapienza, P., & Zingales, L., 2004. The Role of Social Capital in Financial Development. *American Economic Review*, *94*(3), 526–556.

Guiso, L., Sapienza, P., & Zingales, L., 2008. Trusting the Stock Market. *The Journal of Finance*, *63*(6), 2557–2600.

Harhoff, D. and T. Körting, 1998. Lending relationships in Germany – empirical evidence from survey data. *Journal of Banking and Finance* 22(10): 1317-1353.

Hasan, I., C. Hoi, Q. Wu, and H. Zhang, 2017. Social Capital and Debt Contracting: Evidence from Bank Loans and Public Bonds, *Journal of Financial and Quantitative Analysis*, 52(3): 1017- 1047.

Hochberg, Y., A. Ljungqvist and Y. Lu, 2007. Whom You Know Matters: Venture Capital Networks and Investment Performance, *Journal of Finance*, 62(1): 251-301.

Iori, G., G. De Masi, O. V. Precup, G. Gabbi, and G. Caldarelli, 2008. A Network Analysis of the Italian Overnight Money Market, *Journal of Economic Dynamic and Control*, 32: 259-278.

Iyer, R. and Peydro, L., 2011. Interbank contagion at work: evidence from a natural experiment, *Review of Financial Studies* 24(4): 1337-1377.

Iyer, R., Peydro, J. L., da-Rocha-Lopes, S. and A. Schoar, 2014. Interbank Liquidity Crunch and the Firm Credit Crunch: Evidence from the 2007-2009 Crisis. *Review of Financial Studies* 27(1):347-372.

Jackson, M., 2008. Networks in the Understanding of Economic Behaviors, *Journal of Economic Perspectives*, 28(4): 3-22.

Kaufmann, D. A. Kraay, and M. Mastruzzi, 1999. Aggregating Governance Indicators, World Bank Policy Research Working Paper No. 2195.

Kaufmann,D., A. Kraay and M. Mastruzzi, 2010. The Worldwide Governance Indicators : A Summary of Methodology, Data and Analytical Issues. World Bank Policy Research Working Paper No. 5430.

King, T., 2008. Discipline and Liquidity in the Interbank Market. *Journal of Money, Credit and Banking*, 40(2-3): 295-317.

Knack, S., and Keefer, P., 1997. Does Social Capital Have an Economic Payoff? A Cross-Country Investigation. *The Quarterly Journal of Economics*, *112*(4).

Koo, R.C., 2014. *The Escape from Balance Sheet Recession and the QE Trap: A Hazardous Road for the World Economy*. John Wiley and Sons.

Laeven, L., and R. Levine, 2009. Bank Governance, Regulation and Risk Taking. *Journal of Financial Economics*, 93(2): 259-275.

Laeven, L., and F. Valencia, 2013. Systemic Banking Crises Database, *IMF Economic Review* 61: 225–270.

Larcher, D., E. So, and C. Wang. 2013. Boardroom Centrality and Firm Performance. *Journal of Accounting and Economics*, 55: 225-250.

Lee, C.C., and M.F. Hsieh, 2014. Bank Reforms, Foreign Ownership, and Financial Stability. *Journal of International Money and Finance* 40: 204-224.

Levine, R., 1998. The Legal Environment, Banks, and Long-run Economic Growth. *Journal of Money, Credit and Banking*, 30(3): 596-613.

Levine, R., C. Lin and W. Xie, 2018. Corporate Resilience to Banking Crises: The Roles of Trust and Trade Credit. *Journal of Financial and Quantitative Analysis*, 53(4): 1441-1477.

La Porta, R., F. Lopez-de-Silances, A. Shleifer and R. Vishny, 1998. Law and Finance, *Journal of Political Economy*, 106(6): 1113-1155.

Mitchener, K., and G. Richardson, 2019. Network Contagion and Interbank Amplification During the Great Depression. *Journal of Political Economy*. 127(2): 465-507.

Qian, J. and P. Strahan, 2007. How laws and institutions shape financial contracts: The case of bank loans, *Journal of Finance*, 62(6): 2803-2834.

Rochet, J.C. and J. Tirole, 1996. Interbank lending and systemic risk. *Journal of Money, Credit and Banking*, 28(4): 733-762.

Schaeck, K., Cihak, M.,and Wolfe, S., 2009. Are Competitive Banking Systems More Stable? *Journal of Money, Credit and Banking*, 41(4), 711–734.

Westernhagen, N.V., Harada, E., Nagata, T., Vale, B., Ayuso, J., Saurina, J., Daltung, S., Ziegler, S., Kent, E., Reidhill, J. and Peristiani, S., 2004. Bank failures in mature economies. *Basel Committee on Banking Supervision Working Paper*, 13.

Figure 1A. Breakdown of 10-year-average bank assets: 2000-2009

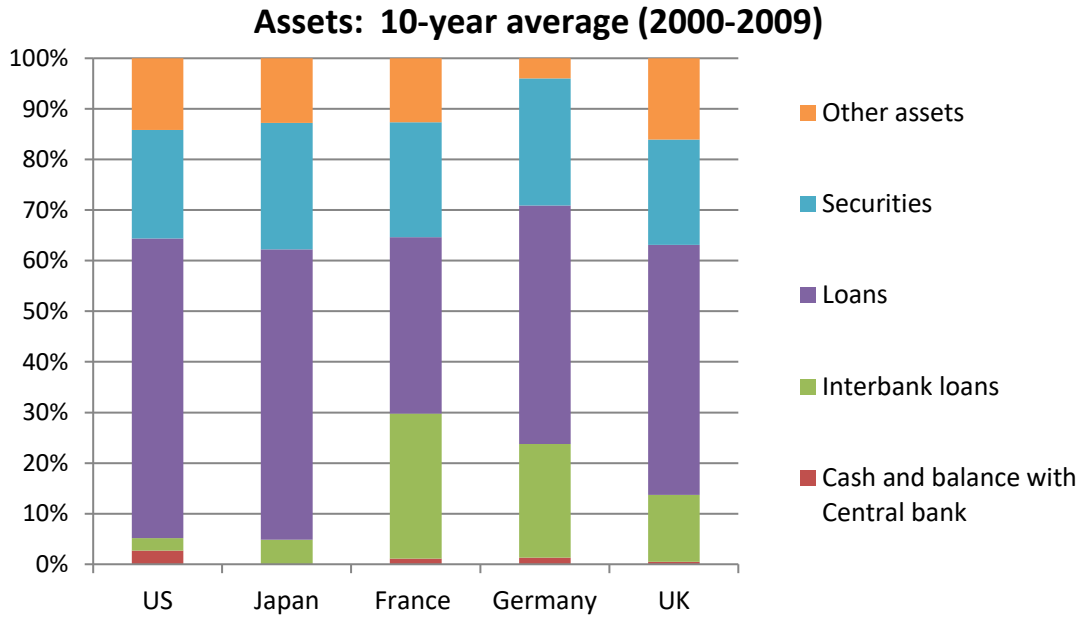
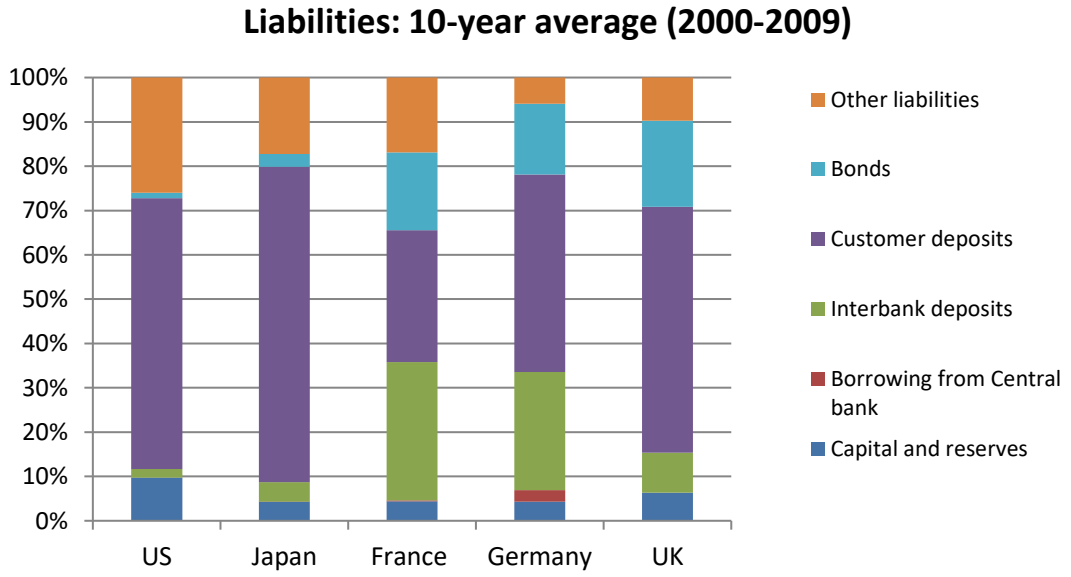


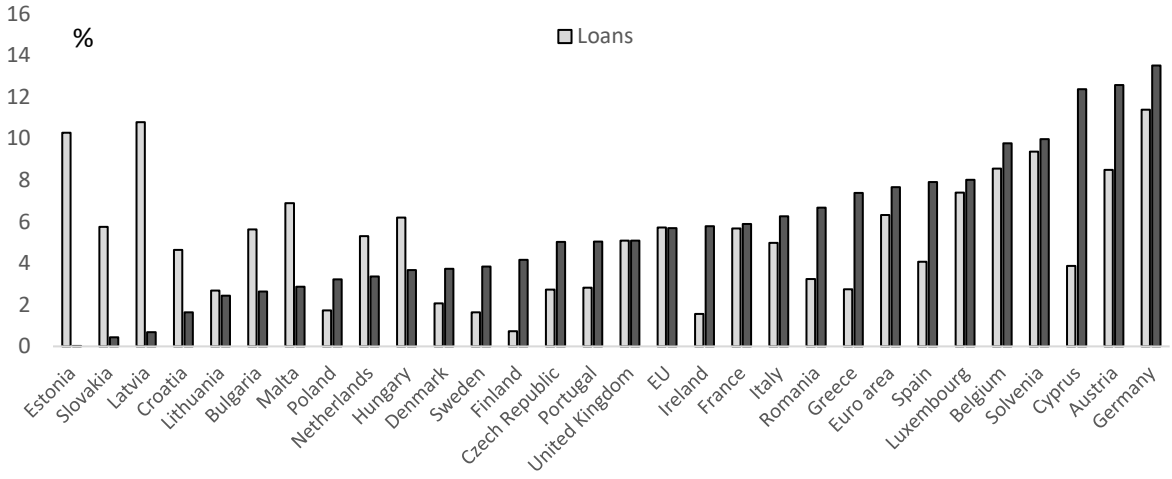
Figure 1B. Breakdown of 10-year-average bank liabilities: 2000-2009



Source: OECD Statistics; Japanese Banker Association

Figure 2. Interbank loans and deposits of domestic banks in the European Union countries in 2016

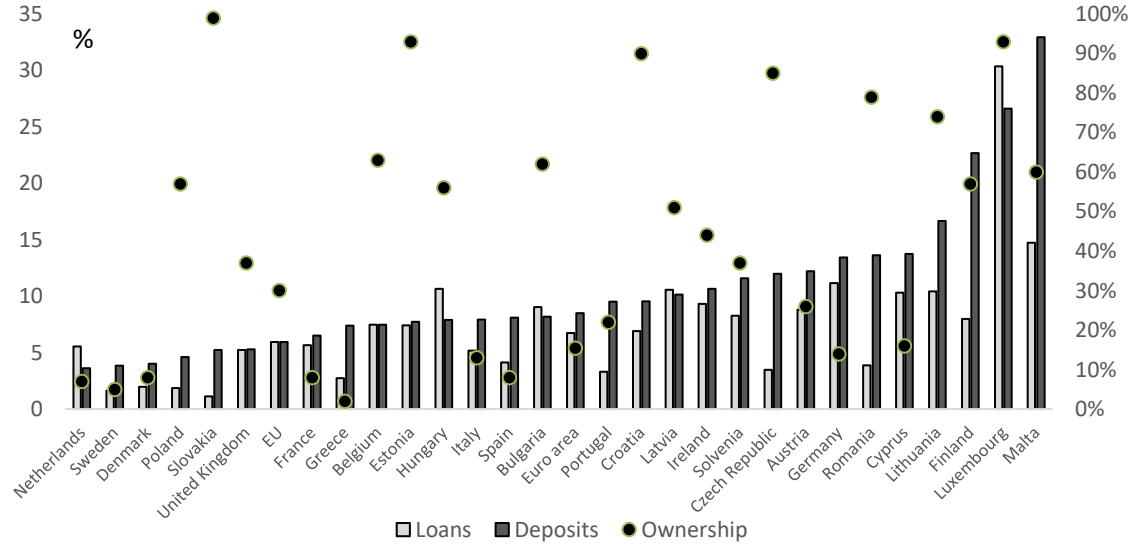
The figure shows the interbank loans and deposits as % of total assets of all domestic banking groups and stand-alone banks in 2016. The data for United Kingdom is for the year 2015.



Source: ECB

Figure 3. Interbank loans and deposits of domestic and foreign banks in the European Union countries in 2016.

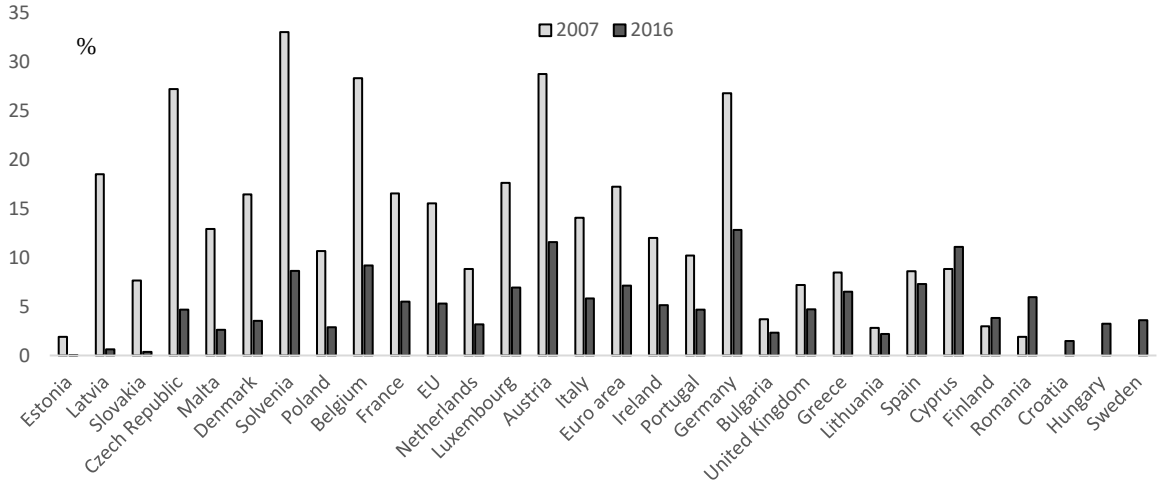
The figure shows the interbank loans and deposits as % of total assets of domestic banking groups and stand-alone banks, foreign (EU and non-EU) controlled subsidiaries and foreign (EU and non-EU) controlled branches, in 2016 left-hand scale). The points present the share of foreign bank ownership as % of total assets (right-hand scale). The data for United Kingdom is for the year 2015.



Source: ECB

Figure 4. Interbank dependence ratio for domestic banks in the European Union countries in the years 2007 and 2016

The figure presents the *interbank market dependence ratio, defined as total amount owed to credit institutions over total assets, for* all domestic banking groups and stand-alone banks in the years 2007 and 2016. The data for Cyprus, Denmark, Estonia, Ireland, Germany, Luxembourg, Latvia, Netherlands, and United Kingdom is for the year 2008.



Source: ECB

Figure 5. Distribution of the length of banking crises over the whole sample period

This figure plots the distribution of the number of countries that have different length (number of years) of banking crises from 1970-2015 in our sample period. Over 20 countries in our sample have no banking crises during this period; 52% have banking crisis of fewer than four years in total; whereas 48% have banking crisis of four or more years in total this period.

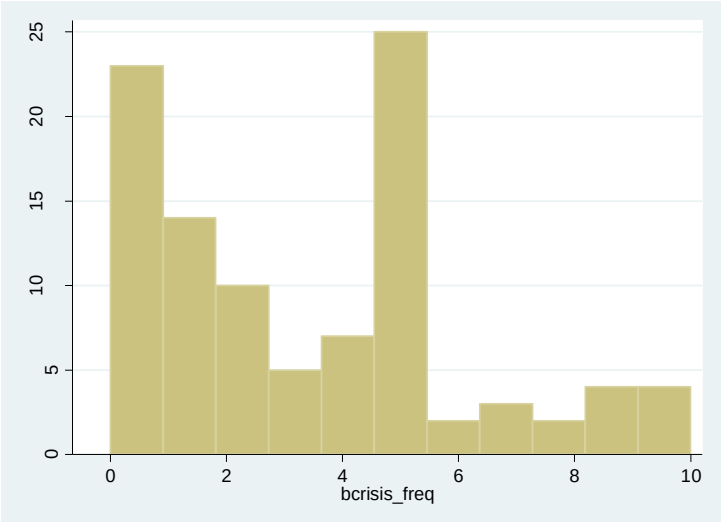


Figure 6. Euro area interbank network

Figure 6A. Euro area interbank network: grouped and colored by country
This chart plots the interbank network (borrowing and lending) of Euro area in 2018Q4. Node size represents eigenvector centrality. Edge colour represents the country receiving the exposures. Node colour refers to different countries as below. The algorithm of the layout is *Multigravity Force Atlas 2.*
Red: Germany; Blue: Non-EA Banks; Black: France; Green: Italy; Yellow: Spain; Orange: Netherlands; Pink: Austria.

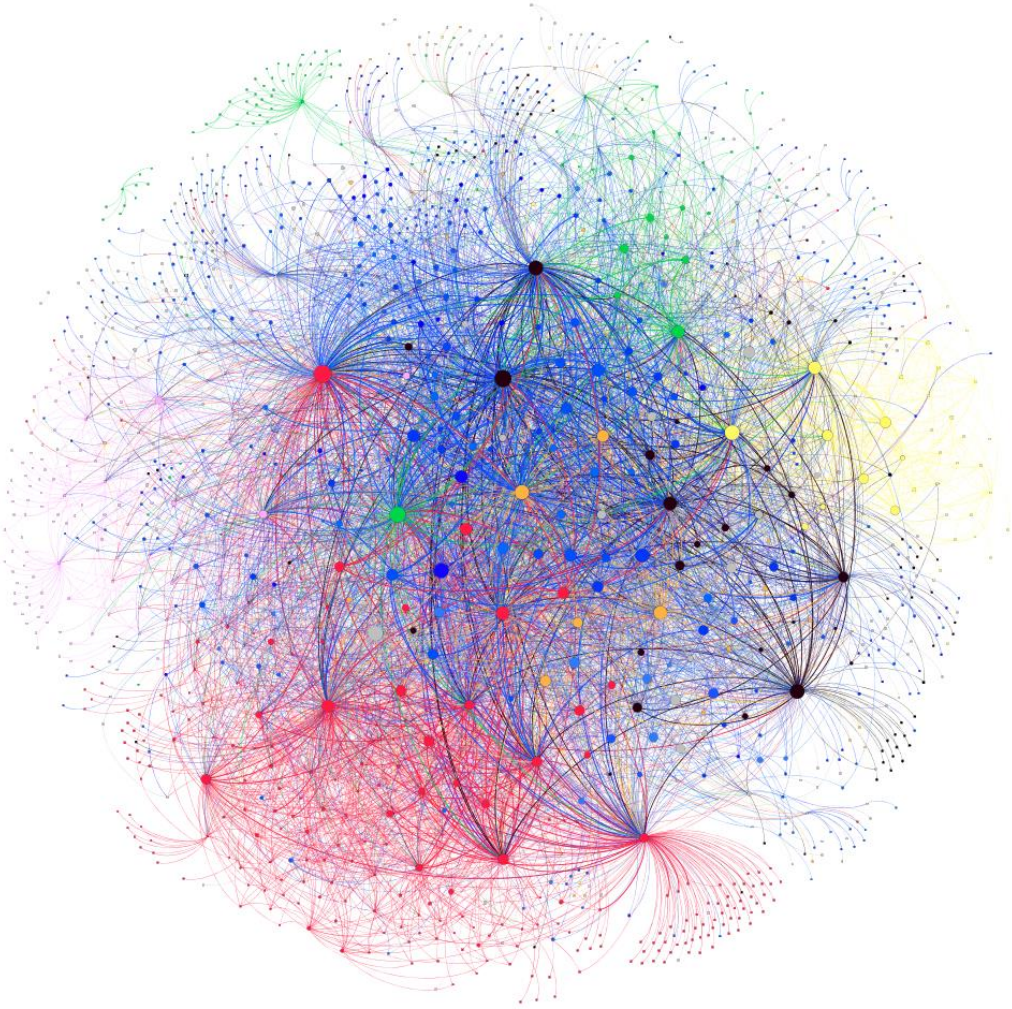


Figure 6B. Euro area interbank network: colored by community
This chart plots the interbank network (borrowing and lending) of Euro area in 2018Q4. Node size represents eigenvector centrality. Edge colour represents the country receiving the exposures. Node colour refers to communities detected using *Modularity*. There are 13 communities in the chart. The algorithm of the layout is *Multigravity Force Atlas 2.*

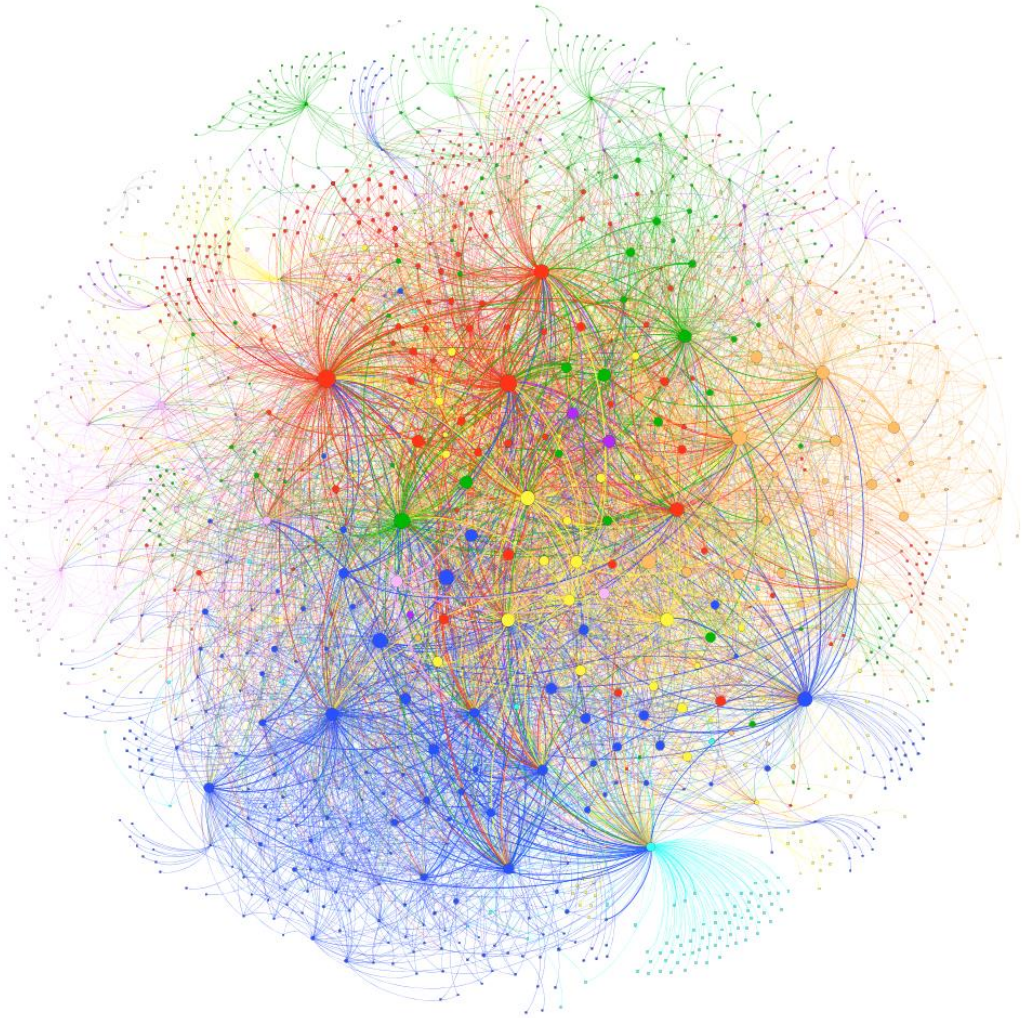


Figure 7. Average weighted indegree and eigenvector across time: 2014-2019
This figure plots the quarterly mean value of weighted in-degree and eigenvector centrality of the network of total exposure, from 2014 to 2019,

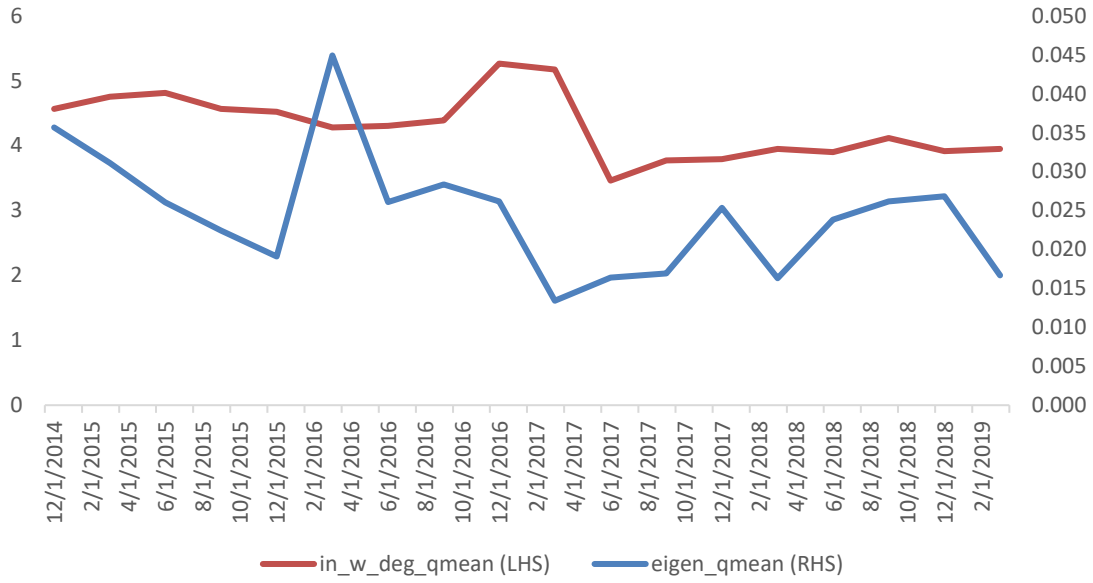


Table 1. Comparative statistics: ratios of interbank deposits and loans

The table presents the comparative statistics of the ratios of interbank deposits and interbank loans for the five countries - the US, the UK, Japan, Germany and France from 2000 to 2014. We calculate interbank deposits as borrowing or deposits from banks and interbank loans as funds due to banks.

Country	Germany		France		UK		Japan		US	
	Interbank deposits	*Interbank loans*	*Interbank deposits*	*Interbank loans*	*Interbank deposits*	*Interbank loans*	*Interbank deposits*	*Interbank loans*	*Interbank deposits*	*Interbank loans*
2000	29.17%	25.52%	36.09%	32.00%	8.02%	13.22%	3.00%	3.94%	6.88%	4.43%
2001	28.94%	26.42%	34.84%	32.27%	8.52%	13.74%	2.56%	3.75%	7.05%	4.87%
2002	28.87%	27.80%	35.49%	32.62%	9.73%	14.38%	2.38%	5.21%	6.71%	5.01%
2003	28.29%	27.89%	34.08%	30.55%	9.54%	13.74%	1.97%	4.48%	5.91%	4.21%
2004	28.31%	28.48%	34.75%	30.70%	10.30%	13.94%	1.91%	4.25%	5.48%	4.13%
2005	28.45%	29.29%	34.85%	30.50%	10.44%	13.95%	1.81%	4.62%	4.66%	3.46%
2006	28.48%	29.94%	34.83%	29.37%	12.44%	16.06%	1.76%	3.86%	4.60%	3.81%
2007	29.21%	31.57%	36.01%	30.38%	5.68%	10.12%	2.78%	2.68%	4.84%	4.25%
2008	28.96%	32.14%	35.49%	29.53%	6.50%	10.97%	2.57%	3.04%	3.37%	2.63%
2009	26.56%	29.65%	33.32%	28.72%	9.05%	11.92%	3.97%	2.98%	2.46%	1.86%
2010	23.44%	26.12%	31.28%	28.18%	7.93%	8.04%	3.31%	2.96%	2.15%	1.57%
2011	21.83%	26.59%	32.07%	30.97%	8.87%	8.93%	4.90%	4.34%	1.17%	0.93%
2012	21.84%	26.46%	31.70%	30.45%	9.67%	9.76%	4.43%	3.76%	1.29%	0.98%
2013	21.64%	26.84%	30.84%	30.31%	11.27%	11.03%	3.38%	4.81%	1.06%	0.78%
2014	21.76%	26.21%	30.62%	30.03%	8.08%	7.86%	3.76%	10.45%	0.83%	0.55%
Average	26.38%	28.06%	33.75%	30.44%	9.07%	11.84%	2.97%	4.34%	3.90%	2.90%

Source: ECB; Bank of England; Japanese Bank Association; FRB.

Table 2. Summary statistics

This table presents the summary statistics of the cross-country bank sample, as well as the difference in characteristics for banks located in countries with long or short periods of bank crises over the sample period.

Panel A Summary statistics: Bank-level full sample

	Obs	*Mean*	*Std. Dev.*	*Min*	*Max*
Interbank borrowing	74,572	0.0775	0.1107	0.0000	1.0000
LtD	74,572	0.9271	0.5621	0.0657	5.4421
Securities	74,572	0.2135	0.1494	0.0000	0.9903
Equity	74,572	0.0947	0.0534	0.0147	0.3309
ROA	74,572	0.0054	0.0103	-0.0606	0.0727
Bank Size	74,572	5.6665	1.4427	2.0175	11.2559
Crisis length	74,572	2.8842	2.4051	0.0000	10.0000
Bank failure	74,572	5.6841	7.4056	-0.1304	16.3184
Bank Z-score	74,195	2.9905	2.7138	-0.3123	11.4330
Common law	73,860	0.3517	0.4775	0.0000	1.0000
Rule of law	72,245	1.2728	0.7560	-1.8900	2.1200
Reg. quality	72,212	1.1628	0.5810	-2.1500	2.2500
Gov. effect	72,212	1.3133	0.6904	-1.7100	2.3600
Private credit	73,535	0.7884	0.3481	0.0115	2.6246
Market Cap.	72,803	0.7471	0.4832	0.0001	8.5733
Central Bank	73,556	0.0643	0.0737	0.0000	1.1358
Concentration	69,682	0.5515	0.2084	0.2228	1.0000

Panel B Comparison of bank characteristics: longer vs shorter periods of banking crisis country

	Long	*Obs.*	*Short*	*Obs.*	*Diff*
Interbank borrowing	0.020	33,966	0.123	33,966	0.103***
	(0.000)		(0.001)		(0.001)
LtD	0.862	33,966	0.993	33,966	0.131***
	(0.003)		(0.003)		(0.004)
Securities	0.216	33,966	0.214	33,966	-0.002
	(0.000)		(0.001)		(0.001)
Equity	0.114	33,966	0.083	33,966	-0.031***
	(0.000)		(0.000)		(0.000)
ROA	0.006	33,966	0.004	33,966	-0.002*
	(0.000)		(0.000)		(0.000)

Table 3. Determinants of interbank borrowing: the role of trust

This table reports the results of the regressions examining the determinants of interbank borrowing using the full bank-level sample of 11,412 banks in 96 countries. The dependent variable is the size of interbank borrowing to total assets. The key explanatory variable is trust, proxied by *Crisis length* (the number of years of crisis) and *Bank Failure* (standardized value of total assets of failed banks). We control for both bank and country characteristics in the regressions. All the other variables are defined in Appendix Table A1. Robust standard errors are reported in parentheses. ***, ** and * denote statistical significance at the 1%, 5% and 10% level, respectively.

Dep Var.	*Interbank borrowing*					
	(1)	(2)	(3)	(4)	(5)	(6)
Trust measure						
Crisis length	-0.00336***	-0.00346***	-0.00331***			
	(0.000309)	(0.000309)	(0.000309)			
Bank Failure				-0.00189***	-0.00105***	-0.00210***
				(0.000267)	(0.000277)	(0.000263)
Bank characteristics						
LtD	0.0685***	0.0667***	0.0687***	0.0700***	0.0679***	0.0700***
	(0.00179)	(0.00177)	(0.00180)	(0.00177)	(0.00175)	(0.00177)
Securities	0.0839***	0.0840***	0.0842***	0.0874***	0.0872***	0.0878***
	(0.00341)	(0.00343)	(0.00341)	(0.00337)	(0.00340)	(0.00337)
Equity	-0.191***	-0.207***	-0.184***	-0.204***	-0.222***	-0.197***
	(0.0103)	(0.0103)	(0.0103)	(0.0101)	(0.0101)	(0.0101)
ROA	-0.0492	-0.0714*	-0.0594	-0.0558	-0.0716*	-0.0721*
	(0.0399)	(0.0399)	(0.0399)	(0.0397)	(0.0398)	(0.0398)
Size	0.0101***	0.00990***	0.0101***	0.00950***	0.00950***	0.00945***
	(0.000289)	(0.000290)	(0.000288)	(0.000285)	(0.000287)	(0.000284)
Country characteristics						
Common law	0.0345***	0.0441***	0.0364***	0.0538***	0.0556***	0.0589***
	(0.00244)	(0.00239)	(0.00240)	(0.00390)	(0.00400)	(0.00392)
Rule of law	0.0215***			0.0262***		
	(0.000901)			(0.00104)		
Reg. quality		0.0196***			0.0236***	

		(0.00112)			(0.00135)	
Gov. effect			0.0263***			0.0319***
			(0.00103)			(0.00117)
Private credit	0.00984***	0.0182***	0.00693***	0.00841***	0.0192***	0.00487*
	(0.00249)	(0.00244)	(0.00248)	(0.00253)	(0.00249)	(0.00253)
Mkt. cap.	-0.0500***	-0.0497***	-0.0528***	-0.0489***	-0.0496***	-0.0519***
	(0.00202)	(0.00199)	(0.00212)	(0.00206)	(0.00205)	(0.00215)
Central bank	-0.276***	-0.264***	-0.274***	-0.290***	-0.275***	-0.287***
	(0.0113)	(0.0112)	(0.0114)	(0.0115)	(0.0113)	(0.0116)
Concentration	0.118***	0.126***	0.118***	0.106***	0.120***	0.106***
	(0.00492)	(0.00489)	(0.00490)	(0.00516)	(0.00519)	(0.00512)
Cons.	-0.0732***	-0.0773***	-0.0809***	-0.0700***	-0.0785***	-0.0784***
	(0.00541)	(0.00543)	(0.00549)	(0.00534)	(0.00538)	(0.00540)
Year FE	YES	YES	YES	YES	YES	YES
# of obs.	67119	67119	67119	67119	67119	67119
Adj. R^2	0.438	0.434	0.440	0.437	0.432	0.440

Table 4. Interbank borrowing and bankruptcy risk

This table reports the results of the regressions examining the determinants of interbank borrowing using the full bank-level sample of 11,412 banks in 96 countries. The dependent variable is the size of interbank borrowing to total assets. The key explanatory variable is bankruptcy risk, measured by *Bank zscore*. We control for both bank and country characteristics in the regressions. All the other variables are defined in Appendix Table A1. Robust standard errors are reported in parentheses. ***, ** and * denote statistical significance at the 1%, 5% and 10% level, respectively.

Dep Var.	*Interbank borrowing*					
	(1)	(2)	(3)	(4)	(5)	(6)
	Full sample			Sample excl. US banks		
Bank characteristics						
Bank zscore	-0.00107***	-0.00104***	-0.00104***	-0.00153***	-0.00156***	-0.00148***
	(0.000145)	(0.000145)	(0.000145)	(0.000197)	(0.000197)	(0.000197)
LtD	0.0693***	0.0674***	0.0694***	0.0698***	0.0677***	0.0698***
	(0.00177)	(0.00176)	(0.00178)	(0.00183)	(0.00182)	(0.00183)
Securities	0.0896***	0.0895***	0.0899***	0.0780***	0.0790***	0.0789***
	(0.00346)	(0.00348)	(0.00346)	(0.00592)	(0.00600)	(0.00592)
Equity	-0.209***	-0.225***	-0.202***	-0.236***	-0.260***	-0.224***
	(0.0101)	(0.0100)	(0.0101)	(0.0145)	(0.0144)	(0.0146)
ROA	0.0389	0.0168	0.0251	-0.0256	-0.0609	-0.0643
	(0.0413)	(0.0413)	(0.0412)	(0.0816)	(0.0818)	(0.0813)
Size	0.00990***	0.00971***	0.00991***	0.0123***	0.0122***	0.0122***
	(0.000286)	(0.000288)	(0.000286)	(0.000397)	(0.000400)	(0.000395)
Country characteristics						
Common law	0.0350***	0.0448***	0.0373***	0.0573***	0.0593***	0.0626***
	(0.00244)	(0.00240)	(0.00241)	(0.00409)	(0.00419)	(0.00412)
Rule of law	0.0227***			0.0269***		
	(0.000899)			(0.00107)		
Reg. quality		0.0214***			0.0249***	
		(0.00111)			(0.00141)	
Gov. effect			0.0274***			0.0325***
			(0.00103)			(0.00121)
Private credit	0.0136***	0.0221***	0.0108***	0.00489*	0.0150***	0.00153
	(0.00250)	(0.00245)	(0.00250)	(0.00260)	(0.00258)	(0.00260)
Mkt. cap.	-0.0492***	-0.0490***	-0.0521***	-0.0475***	-0.0480***	-0.0507***
	(0.00209)	(0.00206)	(0.00220)	(0.00228)	(0.00225)	(0.00239)
Central bank	-0.298***	-0.285***	-0.295***	-0.335***	-0.326***	-0.332***
	(0.0116)	(0.0115)	(0.0117)	(0.0128)	(0.0127)	(0.0129)
Concentration	0.119***	0.127***	0.120***	0.105***	0.116***	0.105***
	(0.00496)	(0.00494)	(0.00494)	(0.00528)	(0.00531)	(0.00525)
Cons.	-0.0771***	-0.0817***	-0.0851***	-0.0743***	-0.0801***	-0.0834***
	(0.00538)	(0.00540)	(0.00545)	(0.00595)	(0.00599)	(0.00602)
Year FE	YES	YES	YES	YES	YES	YES
# of obs.	66854	66854	66854	42543	42543	42543
Adj. R^2	0.438	0.434	0.440	0.298	0.291	0.301

Table 5. Trust in the interbank market: matched sample

This table reports the results of the regressions examining the role of banking crises in affecting interbank borrowing, using the bank-level sample of 6,792 banks over 95 countries (excl. US banks). The dependent variable is interbank borrowing to banks total assets. *Treated* equals 1 if a bank is located country has no less than five banking crises in the years 1970-2015 (47 countries in total), and 0 otherwise. The control sample is defined by one-to-one propensity-score-matching algorithm based on a country's financial structure (*Private credit* and *Mkt. cap.*). We control for both bank and country characteristics in the regressions. All the other variables are defined in Appendix Table A1. Robust standard errors are reported in parentheses. ***, ** and * denote statistical significance at the 1%, 5% and 10% level, respectively.

Dep. Var	*Interbank borrowing*		
	(1)	(2)	(3)
Treated	-0.0177***	-0.0143***	-0.0206***
	(0.00167)	(0.00166)	(0.00169)
LtD	0.0649***	0.0628***	0.0649***
	(0.00187)	(0.00187)	(0.00187)
Securities	0.0715***	0.0725***	0.0716***
	(0.00628)	(0.00633)	(0.00627)
Equity	-0.161***	-0.188***	-0.151***
	(0.0154)	(0.0154)	(0.0155)
ROA	-0.154*	-0.195**	-0.192**
	(0.0847)	(0.0848)	(0.0843)
Banksize	0.0146***	0.0142***	0.0143***
	(0.000430)	(0.000432)	(0.000427)
Rule of law	0.0311***		
	(0.00114)		
Reg. quality		0.0302***	
		(0.00147)	
Gov. effect			0.0362***
			(0.00129)
Private credit	-0.00808***	0.00390	-0.00763***
	(0.00256)	(0.00250)	(0.00253)
Mkt. cap.	-0.0370***	-0.0385***	-0.0418***
	(0.00187)	(0.00187)	(0.00186)
Central bank	-0.333***	-0.324***	-0.329***
	(0.0139)	(0.0137)	(0.0139)
Concentration	0.0627***	0.0784***	0.0613***
	(0.00660)	(0.00658)	(0.00667)
Cons.	-0.0557***	-0.0643***	-0.0647***
	(0.00665)	(0.00668)	(0.00664)
Year FE	YES	YES	YES
# of obs.	38556	38556	38556
Adj. R^2	0.284	0.275	0.286

Table 6. Trust in the interbank market: the mitigating role of institutional factors
This table reports the results of the regressions examining the role of institutions including legal enforcement, regulation quality, and government effectiveness in mitigating the effect of crises on interbank borrowing, using the bank-level sample of 6,792 banks over 95 countries (excl. US banks). The dependent variable is the size of interbank borrowing to total assets. The key explanatory variable is *Crisis length*. We control for both bank and country characteristics in the regressions. All the other variables are defined in the Appendix Table A1. Robust standard errors are in parentheses. ***, ** and * denote statistical significance at the 1%, 5% and 10% level, respectively.

Dep. Var	*Interbank borrowing*		
	(1)	(2)	(3)
Crisis length	-0.00267***	-0.00249***	-0.00266***
	(0.000324)	(0.000325)	(0.000325)
Crisis	-0.0272***	-0.0366***	-0.0236***
	(0.00282)	(0.00341)	(0.00297)
LtD	0.0724***	0.0704***	0.0718***
	(0.00192)	(0.00190)	(0.00191)
Securities	0.0718***	0.0729***	0.0716***
	(0.00594)	(0.00599)	(0.00594)
Equity	-0.203***	-0.224***	-0.195***
	(0.0148)	(0.0148)	(0.0149)
ROA	-0.182**	-0.228***	-0.197**
	(0.0811)	(0.0813)	(0.0809)
Banksize	0.0123***	0.0121***	0.0125***
	(0.000401)	(0.000402)	(0.000400)
Common law	0.0506***	0.0515***	0.0559***
	(0.00409)	(0.00421)	(0.00412)
Private credit	0.00337	0.0146***	-0.0000899
	(0.00261)	(0.00257)	(0.00265)
Mkt. cap.	-0.0486***	-0.0490***	-0.0520***
	(0.00218)	(0.00217)	(0.00229)
Central bank	-0.308***	-0.306***	-0.299***
	(0.0126)	(0.0125)	(0.0125)
Concentration	0.0952***	0.105***	0.0942***
	(0.00541)	(0.00550)	(0.00539)
Rule of law	0.0214***		
	(0.00110)		
Rule of law*Crisis	0.0224***		
	(0.00171)		
Reg. quality		0.0178***	
		(0.00147)	
Reg. quality*Crisis		0.0292***	
		(0.00246)	
Gov. effect			0.0271***
			(0.00125)
Gov. effect*Crisis			0.0238***
			(0.00185)
Cons.	-0.0653***	-0.0699***	-0.0733***
	(0.00598)	(0.00606)	(0.00606)
Year FE	YES	YES	YES
# of obs.	42791	42791	42791
Adj. R^2	0.301	0.294	0.304

Table 7. Robustness check of determinants of interbank borrowing: Euro area banks and Large and Small banks

This table reports the results of the regressions examining the determinants of interbank borrowing using Eurozone banks. The dependent variable is the size of interbank borrowing to total assets. The key explanatory variables are *Crisis length* as well as the interaction term of *Crisis length* and *Large* dummy. *Large* is defined as one for the upper quartile, and zero for the lower quantile based on bank total assets. We control for both bank and country characteristics in the regressions. All the other variables are defined in the Appendix Table A1. Robust standard errors are in parentheses. ***, ** and * denote statistical significance at the 1%, 5% and 10% level, respectively.

Dep. Var	*Interbank borrowing*		
	(1)	(2)	(3)
	EU11	EU19	EU19
Crisis length	-0.0157***	-0.0168***	-0.0116***
	(0.00112)	(0.00114)	(0.00136)
Large			0.0384***
			(0.00212)
Crisis length* Large			-0.00705***
			(0.000650)
LtD	0.134***	0.132***	0.138***
	(0.00258)	(0.00260)	(0.00328)
Securities	0.154***	0.144***	0.129***
	(0.00647)	(0.00653)	(0.00837)
Equity	-0.335***	-0.352***	-0.394***
	(0.0227)	(0.0232)	(0.0262)
ROA	-0.330**	-0.393***	-0.214
	(0.143)	(0.143)	(0.189)
Banksize	0.00794***	0.00858***	
	(0.000491)	(0.000493)	
Common law	-0.0123	-0.0102	-0.0457
	(0.0432)	(0.0430)	(0.0399)
Private credit	0.0654***	0.0654***	0.0459***
	(0.00457)	(0.00464)	(0.00597)
Mkt. cap.	0.0594***	0.0586***	0.0523***
	(0.00693)	(0.00698)	(0.00782)
Central bank	-1.740***	-1.502***	-1.460***
	(0.0496)	(0.0595)	(0.0699)
Concentration	0.0620***	0.0979***	0.0586***
	(0.00795)	(0.00945)	(0.0129)
Cons.	-0.102***	-0.126***	-0.0311**
	(0.00964)	(0.0105)	(0.0137)
Year FE	YES	YES	YES
# of obs.	27855	27949	13986
Adj. R^2	0.452	0.442	0.498

Table 8. Instrumental variable analysis: deposit insurance scheme
This table reports the results of the regressions examining the role of trust in determining the interbank market borrowing using instrumental variable analysis. Column (1) and (3) report the results of the 1st stage, and column (2) and (4) report the results of the 2nd stage. The instrumental variables are *ExDI*, defined as the existence of deposit insurance, and *DI power*, defined as the power of deposit insurance scheme, developed from Demirguc-Kunt, Kane and Laeven (2014). All the other variables are defined in the Appendix Table A1. Robust standard errors are in parentheses. ***, ** and * denote statistical significance at the 1%, 5% and 10% level, respectively.

Dep. Var	*Crisis length*	*Interbank borrowing*	*Crisis length*	*Interbank borrowing*
	(1)	(2)	(3)	(4)
ExDI	1.078***	-0.0386***		
	(0.102)	(0.00361)		
DI power			0.113***	-0.00193**
			(0.0223)	(0.000954)
LtD	-0.490***	0.108***	-0.884***	0.0882***
	(0.0275)	(0.00221)	(0.0397)	(0.00282)
Securities	-1.269***	0.126***	-1.863***	0.100***
	(0.0502)	(0.00360)	(0.0915)	(0.00556)
Equity	4.774***	-0.270***	4.917***	-0.257***
	(0.184)	(0.0105)	(0.277)	(0.0136)
ROA	-0.0763	0.000518	7.724***	-0.0162
	(0.833)	(0.0397)	(1.151)	(0.0500)
Banksize	0.0754***	0.00694***	0.200***	0.00739***
	(0.00602)	(0.000281)	(0.00897)	(0.000399)
Common law	-0.0779	0.0213***	0.867***	0.0413***
	(0.0522)	(0.00282)	(0.0739)	(0.00393)
Rule of law	-0.463***	0.0298***	-0.475***	0.0169***
	(0.0243)	(0.00110)	(0.0299)	(0.00137)
Private credit	-0.723***	0.0105***	0.293***	0.00172
	(0.0606)	(0.00258)	(0.0720)	(0.00289)
Mkt. cap.	0.310***	-0.0497***	0.0861**	-0.0227***
	(0.0287)	(0.00221)	(0.0367)	(0.00256)
Central bank	4.143***	-0.382***	8.820***	-0.398***
	(0.238)	(0.0140)	(0.677)	(0.0359)
Concentration	0.364***	0.0596***	1.652***	0.0578***
	(0.115)	(0.00600)	(0.139)	(0.00716)
Cons.	0.261*	-0.0339***	-0.808***	-0.0486***
	(0.156)	(0.00694)	(0.153)	(0.00785)
Year FE	YES	YES	YES	YES
# of obs.	64722	64722	30968	30968
Adj. R^2	0.718	0.497	0.651	0.397

Table 9. Distribution of country and community of interbank network
This table reports the joint distribution of country and community groups for the network of the forth quarter of 2018. Communities are detected through optimization of *Modularity*.

Country	*Community*													
	0	1	2	3	4	5	6	7	8	9	10	11	12	Total
Austria	1	2	0	5	0	6	7	0	5	0	0	0	88	114
Belgium	0	0	3	0	3	0	1	0	10	0	0	0	0	17
Cyprus	0	0	1	0	0	2	1	0	0	1	0	0	0	5
Estonia	0	0	0	2	2	0	0	0	0	0	0	0	1	5
Finland	1	0	0	0	10	0	0	1	4	0	0	0	1	17
France	4	0	22	4	12	20	2	1	11	1	0	0	0	77
Germany	1	0	3	218	7	10	4	1	4	0	0	0	1	249
Greece	0	0	0	0	0	0	0	0	4	0	2	0	0	6
Ireland	1	0	4	0	1	2	1	7	7	0	0	0	1	24
Italy	1	0	1	1	0	3	85	2	0	0	0	10	0	103
Latvia	0	0	0	1	1	4	1	0	1	0	0	0	6	14
Lithuania	0	0	0	1	2	1	0	0	0	0	0	0	0	4
Luxembourg	3	0	3	2	11	6	3	2	6	0	0	0	1	37
Malta	0	0	0	0	0	1	0	0	3	0	0	0	0	4
Netherlands	2	0	1	1	8	8	6	6	20	0	0	0	0	52
NonEA	59	0	57	30	75	175	72	1	68	0	0	0	32	569
Portugal	11	0	1	0	1	0	0	0	0	0	0	0	0	13
Slovenia	0	0	0	1	0	0	4	0	0	0	0	0	0	5
Spain	38	0	1	0	0	1	2	1	3	0	0	0	1	47
Total	122	2	97	266	133	239	189	22	146	2	2	10	132	1,362

Table 10. Mean value of network measures
This table reports the mean value of network centralities, cluster coefficient as well as average path length over 2014Q4 to 2018Q4 for each country in Euro area.

Country	*Eigenvector*	*Indegree*	*Outdegree*	*Weighted indegree*	*Weighted outdegree*	*Page rank*	*Cluster coefficient*	*Average path length*
France	0.139	26.869	56.364	34.095	25.165	0.0023	0.365	31.852
Belgium	0.040	11.061	20.602	3.739	14.477	0.0008	0.417	112.627
Ireland	0.037	2.351	9.090	2.146	4.425	0.0007	0.332	26.094
Germany	0.036	13.831	25.322	5.469	8.932	0.0014	0.480	38.554
Spain	0.024	9.907	14.884	2.950	6.374	0.0011	0.379	28.693
Netherlands	0.022	11.666	21.018	5.214	8.185	0.0008	0.322	26.939
Italy	0.014	7.452	13.764	1.963	4.880	0.0009	0.411	25.554
Finland	0.004	4.908	6.376	0.658	2.508	0.0007	0.295	418.157
Austria	0.003	4.775	9.479	1.192	1.864	0.0010	0.308	63.153
Portugal	0.002	2.511	6.669	0.277	0.814	0.0006	0.194	35.588
Greece	0.001	1.435	8.978	0.055	3.335	0.0005	0.388	341.234
Luxembourg	0.000	0.939	10.902	0.097	2.199	0.0005	0.258	131.741
Malta	0.000	0.719	6.475	0.054	0.417	0.0005	0.168	36.929
Estonia	0.000	0.290	2.301	0.028	0.366	0.0005	0.235	51.944
Slovenia	0.000	0.312	5.269	0.059	0.313	0.0005	0.455	28.046
Slovakia	0.000	0.306	3.375	0.007	0.083	0.0005	0.377	44.276
Lithuania	0.000	0.211	1.859	0.025	0.642	0.0005	0.223	64.298
Cyprus	0.000	0.155	5.549	0.006	0.664	0.0004	0.179	86.503
Latvia	0.000	0.234	4.133	0.005	0.323	0.0005	0.266	91.605

Table 11. Determinants of interbank market participation: measured by interbank network centrality

This table reports the results of the regressions examining the determinants of interbank market participation, measured by centralities of interbank network. Dependent variables are *Log inwdeg*, *Log page rank*, and *Log eigen*, respectively. The key explanatory variables are *Crisis length* and *Failure ratio*. *Failure ratio* is defined by the total assets of failed banks over total assets of the banking system. *Cluster* is defined as one if the cluster coefficient is above its median, or zero otherwise. All the other variables are defined in the Appendix Table A1. Robust standard errors are in parentheses. ***, ** and * denote statistical significance at the 1%, 5% and 10% level, respectively.

Dep. Var	*Log inwdeg*	*Log page rank*	*Log eigen*	*Log inwdeg*	*Log page rank*	*Log eigen*
	(1)	(2)	(3)	(4)	(5)	(6)
	Total exposures			Exposures within Euro area		
Crisis length	-0.0277*	-0.0000905***	-0.00563***	-0.0289*	-0.000329***	-0.00564***
	(0.0154)	(0.0000290)	(0.00141)	(0.0157)	(0.0000767)	(0.00145)
Failure ratio	-2.914*	-0.00375	-0.339***	-1.576	-0.00843	-0.268**
	(1.525)	(0.00259)	(0.118)	(1.558)	(0.00659)	(0.125)
Cluster	-0.652***	-0.00120***	-0.0278***	-0.708***	-0.00180***	-0.0227***
	(0.0464)	(0.0000964)	(0.00307)	(0.0468)	(0.000170)	(0.00302)
LtD	-0.134***	-0.000453***	-0.0209***	-0.204***	-0.00133***	-0.0256***
	(0.0465)	(0.0000837)	(0.00341)	(0.0447)	(0.000171)	(0.00362)
Securities	-0.775***	-0.00119***	-0.0170	-0.669***	-0.000452	-0.00845
	(0.243)	(0.000448)	(0.0188)	(0.235)	(0.000899)	(0.0192)
ROA	10.04***	0.0141**	0.139	4.802*	0.0136	-0.0464
	(2.768)	(0.00565)	(0.158)	(2.819)	(0.0103)	(0.166)
Equity	-2.077***	-0.00118	-0.0362	-0.170	0.00531***	0.0417
	(0.755)	(0.00112)	(0.0385)	(0.683)	(0.00203)	(0.0402)
Size	0.501***	0.000743***	0.0278***	0.495***	0.00172***	0.0288***
	(0.0153)	(0.0000380)	(0.00179)	(0.0163)	(0.0000925)	(0.00191)
Private credit	-0.00634***	-0.0000113***	-0.000246***	-0.00789***	-0.0000213***	-0.000332***
	(0.000991)	(0.00000190)	(0.0000790)	(0.00111)	(0.00000425)	(0.0000884)
Mkt. cap.	0.000413	-0.0000146***	0.000150	0.000431	-0.0000178***	0.000140
	(0.00127)	(0.00000250)	(0.0000954)	(0.00135)	(0.00000504)	(0.000102)
Concentration	0.00396*	-0.00000640	-0.000136	0.00499**	-0.0000171*	-0.0000743
	(0.00205)	(0.00000415)	(0.000174)	(0.00218)	(0.00000971)	(0.000186)
Cons.	-6.489***	-0.00695***	-0.346***	-6.410***	-0.0191***	-0.366***

	(0.324)	(0.000644)	(0.0269)	(0.336)	(0.00141)	(0.0293)
Quarter FE	YES	YES	YES	YES	YES	YES
# of obs.	1124	1124	1124	1092	1092	1092
Adj. R^2	0.664	0.476	0.482	0.678	0.530	0.477

Table 12. Determinants of interbank market participation: the impact of core vs. periphery positions

The table reports the results of the regressions examining the role of interbank network centrality in affecting trust and interbank market participation. The dependent variable is *Log inwdeg*. The key explanatory variables are *Crisis length* and *Failure ratio*. *Central* is defined as one if the eigenvector centrality is in the upper quartile, or as zero if in the lower quartile. *Log avg length* is the natural logarithm of the average path length for each bank. All the other variables are defined in the Appendix Table A1. Robust standard errors are in parentheses. ***, ** and * denote statistical significance at the 1%, 5% and 10% level, respectively.

Dep. Var	*Log inwdeg*			
	(1)	(2)	(3)	(4)
	Total exposures		Exposures within Euro area	
Crisis length	0.0381	0.0335	0.00574	-0.00218
	(0.0246)	(0.0241)	(0.0241)	(0.0232)
Failure ratio	0.348	0.496	1.836	0.918
	(1.985)	(1.923)	(1.934)	(1.884)
Central	1.505***	1.413***	1.440***	1.383***
	(0.236)	(0.223)	(0.223)	(0.209)
Crisis length * Central	-0.120***	-0.111***	-0.0959***	-0.0883***
	(0.0296)	(0.0285)	(0.0285)	(0.0268)
Failure ratio* Central	-5.995**	-5.649**	-6.538**	-6.166**
	(2.491)	(2.389)	(2.559)	(2.444)
Cluster	-0.630***	-0.614***	-0.508***	-0.489***
	(0.0663)	(0.0650)	(0.0682)	(0.0670)
Log avg length		-18.89***		-25.47***
		(4.159)		(4.653)
LtD	-0.128**	-0.137**	-0.209***	-0.217***
	(0.0588)	(0.0577)	(0.0541)	(0.0526)
Securities	-0.373	-0.411	-0.0302	-0.0490
	(0.322)	(0.316)	(0.292)	(0.287)
ROA	-4.832	-6.721	-5.070	-6.633
	(4.764)	(4.832)	(4.053)	(4.077)
Equity	1.520	1.923*	3.017***	3.069***
	(1.025)	(0.990)	(0.733)	(0.714)
Size	0.449***	0.441***	0.448***	0.426***
	(0.0238)	(0.0233)	(0.0238)	(0.0234)
Private credit	-0.00453***	-0.00502***	-0.00532***	-0.00559***
	(0.00130)	(0.00132)	(0.00135)	(0.00133)
Mkt. cap.	-0.00192	-0.00185	-0.00254*	-0.00167
	(0.00166)	(0.00165)	(0.00147)	(0.00147)
Concentration	0.00879***	0.00853***	0.00600**	0.00657**
	(0.00270)	(0.00266)	(0.00281)	(0.00272)
Cons.	-7.001***	35.19***	-6.722***	52.77***
	(0.477)	(9.335)	(0.496)	(10.91)
Quarter FE	YES	YES	YES	YES
# of obs.	714	714	697	697
Adj. R^2	0.725	0.735	0.735	0.746

Table 13. Determinants of interbank market participation: the role of clustering

The table reports the results of the regressions examining the role of interbank clustering in affecting trust and interbank market participation. The dependent variable is *Log inwdeg*, *Log page rank*, *and Log eigen*, respectively. The key explanatory variables are *Crisis length* and *Failure ratio*. *Cluster* is defined as one if the cluster coefficient is above its median, or zero otherwise. *Log avg length* is the natural logarithm of the average path length for each bank. All the other variables are defined in the Appendix Table A1. Robust standard errors are in parentheses. ***, ** and * denote statistical significance at the 1%, 5% and 10% level, respectively.

Dep. Var	*Log windeg*	*Log page rank*	*Log eigen*	*Log windeg*	*Log page rank*	*Log eigen*
	(1)	(2)	(3)	(4)	(5)	(6)
	Total exposures			Exposures within Euro area		
Crisis length	-0.0583***	-0.000250***	-0.0112***	-0.0592***	-0.000574***	-0.00928***
	(0.0190)	(0.0000419)	(0.00201)	(0.0185)	(0.000101)	(0.00194)
Failure ratio	-6.355***	-0.0180***	-0.727***	-4.947***	-0.0355***	-0.610***
	(1.696)	(0.00328)	(0.148)	(1.809)	(0.00839)	(0.160)
Cluster	-1.107***	-0.00339***	-0.0993***	-1.192***	-0.00571***	-0.0786***
	(0.150)	(0.000314)	(0.0127)	(0.157)	(0.000688)	(0.0123)
Crisis length * Cluster	0.0509**	0.000273***	0.00987***	0.0597***	0.000485***	0.00743***
	(0.0202)	(0.0000398)	(0.00173)	(0.0205)	(0.0000900)	(0.00164)
Failure ratio * Cluster	9.178***	0.0367***	0.945***	8.148***	0.0654***	0.799***
	(1.742)	(0.00358)	(0.138)	(1.864)	(0.00789)	(0.151)
LtD	-0.113**	-0.000347***	-0.0174***	-0.163***	-0.00100***	-0.0215***
	(0.0458)	(0.0000813)	(0.00327)	(0.0461)	(0.000167)	(0.00359)
Securities	-0.794***	-0.00131***	-0.0216	-0.638***	-0.000210	-0.00834
	(0.234)	(0.000462)	(0.0183)	(0.228)	(0.000875)	(0.0189)
ROA	9.170***	0.0102	0.0227	4.053	0.00756	-0.124
	(2.958)	(0.00642)	(0.177)	(2.946)	(0.0111)	(0.176)
Equity	-1.915**	-0.000400	-0.0106	0.187	0.00820***	0.0830*
	(0.763)	(0.00116)	(0.0404)	(0.702)	(0.00221)	(0.0437)
Size	0.504***	0.000754***	0.0281***	0.501***	0.00177***	0.0292***
	(0.0152)	(0.0000373)	(0.00175)	(0.0167)	(0.0000934)	(0.00194)
Private credit	-0.00564***	-0.00000886***	-0.000198**	-0.00732***	-0.0000168***	-0.000280***
	(0.00102)	(0.00000185)	(0.0000783)	(0.00111)	(0.00000428)	(0.0000896)
Mkt. cap.	0.000300	-0.0000147***	0.000164*	0.000644	-0.0000160***	0.000173

	(0.00129)	(0.00000259)	(0.0000974)	(0.00134)	(0.00000522)	(0.000105)
Concentration	0.00179	-0.0000156***	-0.000397**	0.00372*	-0.0000274***	-0.000205
	(0.00201)	(0.00000418)	(0.000182)	(0.00214)	(0.00000971)	(0.000191)
Cons.	-6.253***	-0.00580***	-0.308***	-6.337***	-0.0185***	-0.353***
	(0.332)	(0.000641)	(0.0260)	(0.346)	(0.00140)	(0.0292)
Quarter FE	YES	YES	YES	YES	YES	YES
# of obs.	1124	1124	1124	1092	1092	1092
Adj. R^2	0.670	0.506	0.503	0.682	0.554	0.489

Table 14. Determinants of interbank market participation: non-securities and short-term exposure

This table examines the robustness of the results using the exposures excluding securities and short-term exposures (exposures less than 30 days), from the full sample. The dependent variable is *Log windeg*. The key explanatory variables are the trust measures (*Crisis length* and *Failure ratio*), as well as their interactions with *Central* and *Cluster*. Robust standard errors are in parentheses. ***, ** and * denote statistical significance at the 1%, 5% and 10% level, respectively.

Dep. Var	*Log windeg*	
	(1)	(2)
	Exposures excl. securities	Short-term exposures
Crisis length	0.000734	-0.0141
	(0.0250)	(0.0114)
Failure ratio	3.759	1.214
	(2.302)	(1.088)
Central	2.278***	0.741***
	(0.207)	(0.0918)
Cluster	-1.236***	-0.542***
	(0.214)	(0.106)
Crisis length * Central	-0.170***	-0.0601***
	(0.0279)	(0.0115)
Failure ratio * Central	-17.17***	-6.817***
	(2.420)	(1.062)
Crisis length * Cluster	0.102***	0.0363***
	(0.0298)	(0.0135)
Failure ratio * Cluster	9.370***	5.385***
	(2.597)	(1.225)
Log avg length	-0.0299	-0.0544
	(0.0711)	(0.0742)
LtD	0.0165	-0.145***
	(0.0485)	(0.0328)
Securities	0.0713	0.0958
	(0.323)	(0.166)
ROA	7.008*	3.753**
	(3.787)	(1.610)
Equity	1.592**	1.087**
	(0.809)	(0.489)
Size	0.378***	0.259***
	(0.0269)	(0.0126)
Private credit	-0.00396***	-0.00302***
	(0.00150)	(0.000710)
Mkt. cap.	-0.00225	-0.00122
	(0.00182)	(0.000929)
Concentration	0.00420	-0.000427
	(0.00280)	(0.00141)
Cons.	-5.811***	-3.344***
	(0.656)	(0.513)
Quarter FE	YES	YES
# of obs.	558	1008
Adj. R^2	0.701	0.584

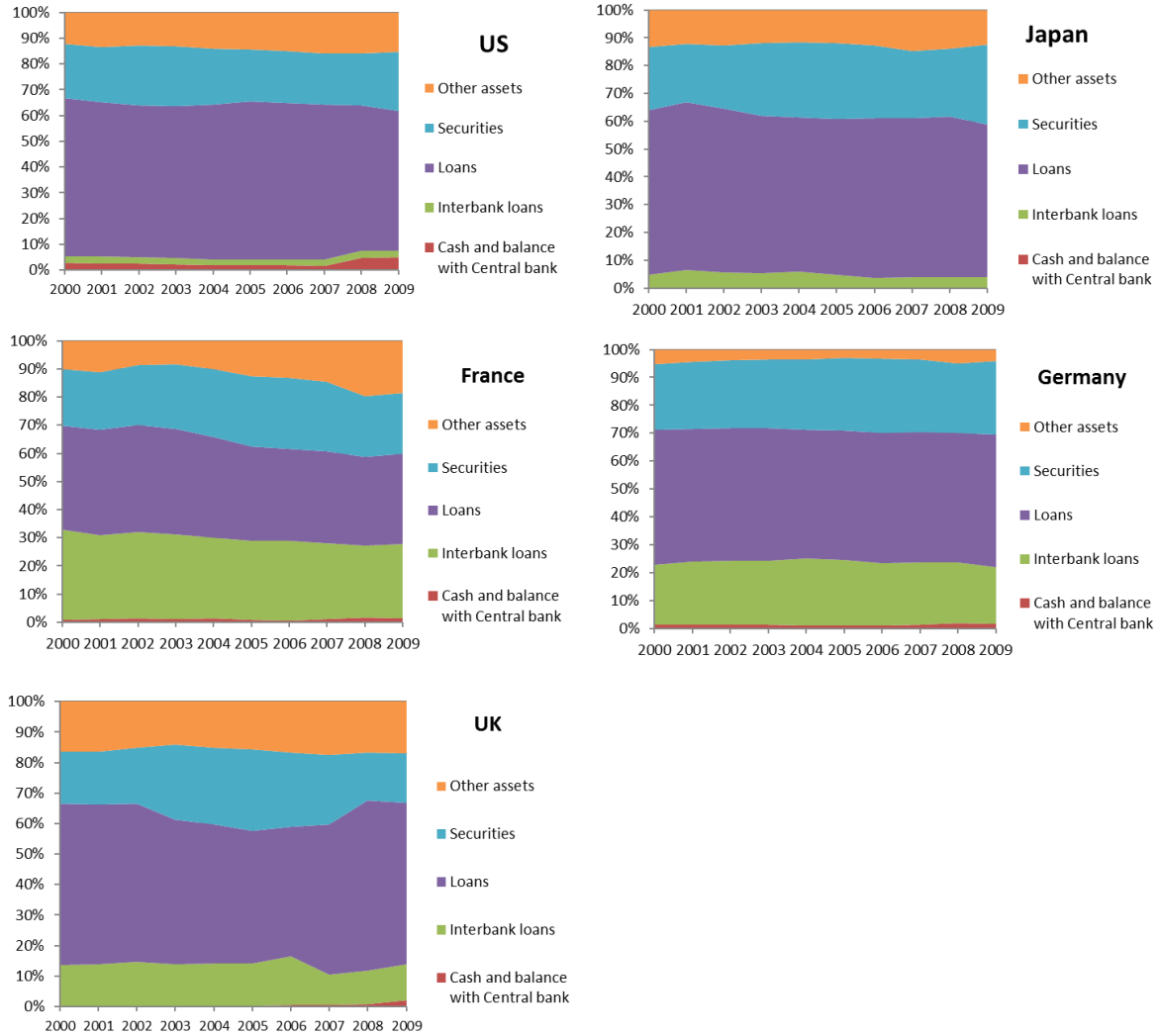
Appendix

Table A1. Variable definitions

Variable	Definitions	Source
Measures of trust in the banking system		
Bank z-score	Ratio of return on assets plus capital-asset-ratio to the standard deviation of return on assets	BankScope/BankFocus
Crisis length	The number of banking crises occurred in each country till year *t*	Laeven and Valencia (2013) and own calculation
Crisis	A dummy variable that takes the value 1 for the years of systemic banking crisis periods and 0 otherwise	
Bank failure	The standardized value of total assets of failed banks in each country till year *t*	BankScope/BankFocus
Failure ratio	The ratio of assets of failed banks to total assets of the banking sector in each country till year *t*	BankScope/BankFocus
Bank level variables		
Balance sheet data		
Interbank borrowing	Borrowing and deposits from banks divided by total assets	BankScope/BankFocus
LtD	Bank's gross nonfinancial loans divided by nonfinancial deposits	
Securities	Securities to total assets	
Equity	Equity to total assets	
ROA	Return on assets	
Size	Natural logarithm of bank's total assets	
Network measures		
Log inwdeg	Natural logarithm of weighted in-degree	European Central Bank, and own calculation
Log page rank	Natural logarithm of page rank centrality	
Log eigen	Natural logarithm of eigenvector centrality	
Central	Equals to 1 if the eigenvector centrality is in the upper quartile, to 0 if the eigenvector centrality is in the the lower quartile	
Cluster	Equals to 1 if the cluster coefficient is above median, or 0 otherwise.	
Log avg length	Natural logarithm of average path length	
Country level variables		
Common law	Equals to 1 if the legal origin of the country is common law.	Djankov et al. (2007)
Rule of law	The index of rule of law	Worldwide Governance Indicator Database (2016)
Reg. quality	The index of regulation quality	
Gov. effect	The index of government effectiveness	
Private credit	Private credit by deposit money banks divided by GDP	
Market cap.	Stock market capitalization divided by GDP	
Concentration	Assets of three largest commercial banks as a share of total commercial banking assets.	World Bank, Global Finance Database (2016)
Central Bank	Central bank total assets divided by GDP	

Internet Appendix

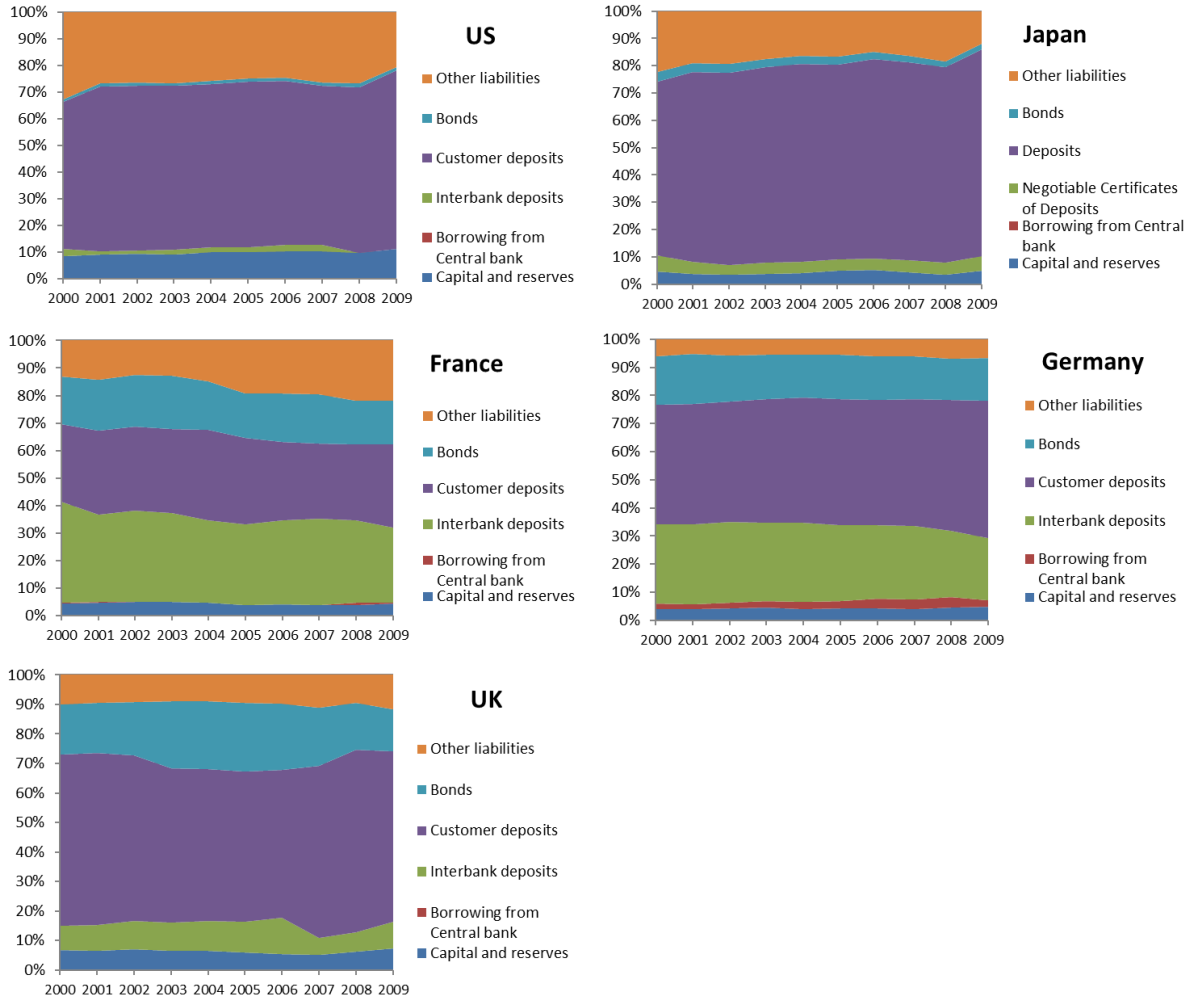
Figure B1. Structure of Bank Assets
This figure plots the structure of bank assets for five countries – the US, Japan, France, Germany and the UK from 2000-2009. The US and Japan have much lower interbank loan ratio (interbank loan/total bank assets), averaging 2.44% and 4.28%, respectively. The UK, Germany, and France have higher interbank loan ratios, averaging 13.20%, 22.48% and 28.68%, respectively.



Source: OECD Statistics; Japanese Banker Association

Figure B2. Structure of Bank Liabilities

This figure plots the structure of bank liabilities for five countries – the US, Japan, France, Germany and the UK. The US and Japan have lower interbank deposit ratio (interbank deposit/total liabilities), averaging 1.95% and 4.41%, respectively. The UK, Germany and France have higher interbank deposit ratios, averaging at 9.02%, 26.61% and 31.19%, respectively.



Source: OECD Statistics; Japanese Banker Association

Table B1. The Interbank Borrowing Size by Country
This table shows the number of banks and the interbank deposit ratio (interbank deposits/total assets) for the countries in our sample. When constructing the sample, we drop those countries with less than five banks in the original dataset.

Country name	Bank number	Interbank borrowing
Argentina	63	4.54%
Australia	8	10.40%
Austria	184	28.07%
Azerbaijan	12	18.20%
Bahamas, The	15	13.97%
Bangladesh	7	5.35%
Belarus	9	10.63%
Belgium	44	17.98%
Bolivia	8	16.98%
Bosnia and Herzegovina	7	2.51%
Brazil	60	3.12%
Bulgaria	8	5.50%
Canada	27	2.09%
Cayman Islands	7	1.35%
China	150	10.74%
Colombia	32	6.26%
Costa Rica	42	12.26%
Cote d'Ivoire	5	23.93%
Croatia	31	1.91%
Curacao	7	6.91%
Cyprus	8	3.36%
Czech Republic	10	34.20%
Denmark	80	17.03%
Dominican Republic	38	1.53%
Ecuador	33	0.48%
Egypt, Arab Rep.	5	4.20%
El Salvador	5	0.00%
Ethiopia	6	2.31%
Finland	35	5.15%
France	174	23.37%
Germany	1879	18.14%
Ghana	5	3.98%
Greece	26	9.66%
Guatemala	27	9.61%
Honduras	10	4.40%
Hong Kong SAR, China	6	8.74%
Hungary	6	16.99%
Iceland	29	11.88%
India	32	6.00%
Indonesia	58	3.62%

Ireland	7	41.81%
Israel	5	14.16%
Italy	1007	13.02%
Japan	464	1.55%
Kazakhstan	9	10.76%
Kenya	24	5.00%
Korea, Rep.	6	0.41%
Lao PDR	5	10.18%
Latvia	5	24.74%
Lebanon	38	4.31%
Libya	6	1.61%
Luxembourg	41	26.94%
Macedonia, FYR	5	3.49%
Malaysia	18	7.47%
Mali	5	15.27%
Mauritania	6	2.65%
Mexico	19	29.32%
Moldova	11	5.24%
Mongolia	10	11.03%
Morocco	7	8.82%
Nepal	5	0.17%
Netherlands	23	22.01%
New Zealand	6	4.61%
Nicaragua	9	21.99%
Nigeria	39	5.05%
Norway	65	10.23%
Oman	5	9.23%
Pakistan	10	12.63%
Panama	28	5.14%
Paraguay	19	9.22%
Peru	10	10.62%
Philippines	23	1.58%
Poland	26	9.20%
Portugal	98	42.20%
Russian Federation	447	9.84%
San Marino	6	2.18%
Senegal	6	13.32%
Serbia	17	4.32%
Singapore	8	12.49%
Slovak Republic	6	12.46%
South Africa	16	22.84%
Spain	203	15.69%
Sweden	90	8.22%
Switzerland	380	10.40%
Tajikistan	6	12.37%
Tanzania	7	6.83%

Thailand	11	2.23%
Turkey	33	4.13%
Ukraine	152	21.52%
United Kingdom	30	14.16%
United States	4621	0.55%
Uruguay	12	11.33%
Uzbekistan	17	7.37%
Venezuela, RB	49	6.38%
Vietnam	26	22.20%
Yemen, Rep.	7	2.76%

Table B2. Determinants of interbank borrowing: Samples excl. the U.S. Banks and financial center

Dep. Var	*Interbank borrowing*					
	(1)	(2)	(3)	(4)	(5)	(6)
	Sample excl. US banks			*Sample excl. US banks and financial center*		
Crisis length	-0.00283***	-0.00284***	-0.00277***	-0.00283***	-0.00286***	-0.00277***
	(0.000325)	(0.000325)	(0.000325)	(0.000324)	(0.000324)	(0.000324)
LtD	0.0694***	0.0674***	0.0694***	0.0685***	0.0665***	0.0685***
	(0.00185)	(0.00183)	(0.00185)	(0.00186)	(0.00184)	(0.00186)
Securities	0.0720***	0.0733***	0.0727***	0.0714***	0.0732***	0.0722***
	(0.00595)	(0.00602)	(0.00594)	(0.00596)	(0.00603)	(0.00595)
Equity	-0.213***	-0.237***	-0.202***	-0.225***	-0.249***	-0.214***
	(0.0148)	(0.0147)	(0.0148)	(0.0148)	(0.0147)	(0.0148)
ROA	-0.105	-0.144*	-0.139*	-0.109	-0.152*	-0.141*
	(0.0808)	(0.0810)	(0.0806)	(0.0810)	(0.0811)	(0.0808)
Banksize	0.0126***	0.0125***	0.0126***	0.0124***	0.0123***	0.0124***
	(0.000400)	(0.000403)	(0.000399)	(0.000401)	(0.000403)	(0.000399)
Common law	0.0566***	0.0583***	0.0619***	0.0491***	0.0504***	0.0546***
	(0.00411)	(0.00421)	(0.00414)	(0.00405)	(0.00415)	(0.00407)
Private credit	0.00152	0.0118***	-0.00195	-0.0000604	0.0103***	-0.00340
	(0.00259)	(0.00257)	(0.00259)	(0.00258)	(0.00256)	(0.00258)
Mkt. cap.	-0.0493***	-0.0497***	-0.0523***	-0.0492***	-0.0496***	-0.0521***
	(0.00220)	(0.00218)	(0.00231)	(0.00220)	(0.00218)	(0.00231)
Central bank	-0.306***	-0.297***	-0.303***	-0.304***	-0.296***	-0.302***
	(0.0124)	(0.0123)	(0.0124)	(0.0123)	(0.0122)	(0.0124)
Concentration	0.104***	0.116***	0.104***	0.107***	0.120***	0.107***
	(0.00523)	(0.00526)	(0.00520)	(0.00518)	(0.00521)	(0.00516)
Rule of law	0.0260***			0.0250***		
	(0.00107)			(0.00106)		
Reg. quality		0.0235***			0.0218***	
		(0.00141)			(0.00140)	
Gov. effect			0.0317***			0.0306***
Cons.	-0.0744***	-0.0802***	-0.0832***	-0.0708***	-0.0763***	-0.0793***
	(0.00596)	(0.00601)	(0.00603)	(0.00596)	(0.00601)	(0.00604)
Year FE	Y	Y	Y	Y	Y	Y

# of obs.	42807	42807	42807	42727	42727	42727
Adj. R^2	0.297	0.290	0.300	0.295	0.289	0.298