Interbank Intermediation*

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May 16, 2016

Abstract

This paper explores the economics of interbank lending and borrowing using bank-balance sheet data for Germany, the largest European economy. Our 2002-2014 panel data set allows us to analyze the cross section and the dynamics of the observed interbank exposures. Our findings suggest a genuine intermediation process within the banking system, with implications for allocative efficiency and financial stability. A typical bank in our sample holds a significant amount of term and overnight interbank positions on both sides of the balance sheet simultaneously, and at any point in time. The average contract length in the German interbank market is well above one year, which stands in contrast to the widely held view that interbank exposures are largely overnight. Based on panel regressions, we find the build-up of the interbank book to be driven by innovations in the client book (i.e. non-bank deposit taking and lending). The resulting interbank book affects the bank's duration gap, the maturity disparity between bank assets and bank liabilities. A bank's duration gap is often seen as its major macroeconomic risk factor. Overall our findings lend support to a theory of banking that involves leverage stacks, i.e intermediation among banks.

Keywords: Interbank markets, liquidity, financial stability
JEL Classification: G2

*We would like to thank Christoph Memmel, John Moore, Cheng Hsiao, James Heckman, Warren Bailey, Jan Scheithauer and conference and seminar participants at the Workshop on Theory and Applications in Microeconometrics at Xiamen University, the International Monetary Fund, the Deutsche Bundesbank, and University of Edinburgh for providing useful feedback. Tarik Roukny provided excellent research assistance. The views expressed in this paper are those of the authors and do not necessarily reflect the opinion of the Deutsche Bundesbank.

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1 Introduction

The role of interbank markets in credit allocation and financial stability has been a matter of great concern since the onset of the global financial crisis in 2007. A freeze of overnight lending among banks is one of the stylized facts that has allegedly characterized systemic risk in the years since then. Despite its significance for the banking system, little is known about the actual operation of the interbank market. This paper explores a data set covering exposures among banks in the largest European economy, Germany, for the period 2002-2014, and it focuses on the economic role of interbank funding as a complement to banks' client business. The panel data structure allows us to identify characteristics of exposures among banks in the cross-section, as well as their determinants over time.

Our findings suggest that interbank markets play an important role in providing credit to the real economy, and for financial stability. We find three common features that prevail over the entire sample period. Interbank exposures are a significant part of a typical bank's balance sheet, they are simultaneously held on both sides of the balance sheet, and they consist not only of overnight, but also of term exposures. An average commercial bank in Germany holds 20-25 percent of its assets and liabilities in the form of interbank exposures, and the average maturity of its interbank book is well above one year.

Moreover, we study the dynamics of the interbank book (the sum of all interbank exposures at any moment in time) using panel regressions. We find that innovations in the client book, i.e. the aggregate of all non-bank exposures (deposit inflows from, and lending outflows to retail and corporate clients) play a significant part in explaining the dynamics of the interbank book. The inflow of additional non-bank deposits to a particular bank is correlated with the contemporaneous growth of its interbank lending exposure. Similarly, the outflow of additional loans to non-bank corporate clients is correlated with an extension of that bank's interbank borrowing. Moreover, the build-up of the observed interbank debt layer is roughly in the same maturity bucket as the underlying client

transactions. As a result, we observe an interbank book at the bank level that reflects the underlying client book, in the sense of a *mirror image*.

The observation of a significant extent of interbank intermediation supports the recent suggestion by Moore (2011) describing interbank markets as a way of stacking bank leverage. In his model, banks seek interbank exposures for inflows and outflows resulting from commercial banking business, i.e. deposit taking and lending. The bank book in his model is derivative to the autonomous client book. This is largely consistent with our findings, where marginal changes in the client book (deposit taking and lending) translate significantly into changes of the interbank book. Since these changes tend to be in the same maturity bucket, the observed interbank book will have an impact on the bank's duration gap. This gap is defined as the difference between the weighted maturity of a bank's assets and liabilities, and it is seen as a major source of overall bank risk. More concretely, the duration of a portfolio of assets allows us to forecast how its market value will respond to a 1% change in the interest rate. The observed *stacking* of an interbank book on top of a client book adds maturity transformation congruence to the balance sheet, thereby lowering the individual bank's overall interest rate risk. These results pertain to the German commercial banking segment, and are robust if the entire banking system, including savings and cooperative banks, is considered.

Taken together, our findings suggest a role for the interbank market beyond the provision of overnight liquidity for banks, which has been the essence of much of the theoretical literature on the interbank market, notably Allen and Gale (2000), Freixas et al. (2000), and Freixas and Jorge (2008). Note that these liquidity insurance models of the interbank market suggest gross and net exposure vis-à-vis the interbank market are of comparable magnitude, since, at any given moment in time, an interbank exposure tends to be only on one side of the balance sheet. We find, however, that net and gross exposures differ to a significant degree, in line with the stacked leverage theory. While we find support for a role as insurance provider, we also find that the interbank market allows banks to manage their term structure risk. This explains the build-up of an interbank book, with

exposures on both sides of the balance sheet. In this sense, the stacked leverage theory developed in Moore (2011) is consistent with, and reaches beyond, Allen and Gale (2000). Our findings suggest active term structure management by banks through the interbank market.

The remainder of the paper is organized as follows. In Section 2 we describe our data sources. Section 3 contains a descriptive analysis of these data, focusing on the extent and the duration of interbank exposures. Section 4 formulates the hypotheses, referring to theory and the stylized facts from the previous section, and it explains the empirical strategy. Results are presented in section 5, while section 6 summarizes the findings and discusses further economic and macroeconomic implications of our observations.

2 Data

2.1 Data Sources

Our main data source is the balance sheet statistic (BISTA), which is collected at a monthly frequency. Our data contain balance sheet variables for all German banks, including savings- and loans banks and cooperative banks, from February 2002 to December 2014, i.e. for 155 months. We restrict ourselves to a balanced panel of commercial banks, i.e. to a sample where we have data for all variables of all banks in all months.[1]

[1]Our results are robust if we use a larger sample containing all banks in Germany, including local cooperative banks (Genossenschaftsbanken), savings banks (Sparkassen) as well as their respective head institutions, the cooperative central banks (Genossenschaftszentralbanken) and the savings central banks (Landesbanken). For our main regressions, though, we exclude these banks in order to obtain a cleaner sample and results that are not driven by institutional details, in particular the two-tier structure found in part of the German banking sector.

2.2 Variable Definitions

Our main dependent variable is the normalized change in net interbank lending, Δ Net Interbank Lending, defined as the change in the difference between interbank assets and liabilities from the previous period to the current one, divided by the total asset size in the previous period. In some of our specifications we use the change in gross interbank lending and borrowing from the previous period to the current period, divided by total asset size in the previous period, as the dependent variable. When no maturity segment is specified, we use the total of the dependent variable. For some regressions, however, we distinguish between short- and longer-term segments. We define the short-term segment of the interbank market to be the overnight segment. Every interbank debenture with a maturity longer than overnight is recorded in the term segment.[2]

We use four main independent variables. Loans are claims of banks (monetary financial institutions) on non-banks including firms, other financial intermediaries (e.g. insurance companies and pension funds), households, and the government (i.e. the domestic federal government). Deposits are claims of non-banks including firms, other financial intermediaries, households, and the government on banks. We denote Loans with a maturity of up to one year as short-term, and all Loans with a longer maturity as long-term. Overnight Deposits are denoted overnight, while Deposits with a longer maturity are denoted longer-term.[3]

The overnight interbank market is often described as the market for central bank reserves. Liquidity from the central bank has become increasingly important for commercial banks, in particular since the move to a full-allotment regime of monetary policy in October 2008. We study the effects of unconventional monetary policy in some detail and therefore explicitly include a bank's recourse to central bank liquidity in our regressions. Central

[2]For interbank assets the maturity buckets are overnight, longer than overnight and up to one year, above one year and up to five years, and above five years. For interbank liabilities, the maturity buckets are overnight, longer than overnight and up to one year, above one year and up to two years, and above two years.

[3]The maturity buckets for Loans are up to one year, above one year, but below five years, and above five years. The maturity buckets for Deposits are overnight, above overnight and up to one year, above one year and up to two years, and above two years.

Bank Assets denotes all assets a bank holds at the Deutsche Bundesbank, i.e. mostly the recourse to the deposit facility. However, Central Bank Assets also include assets with a maturity more than overnight once the European Central Bank (ECB) starts its Securities Market Programme. Central Bank Liabilities denote all claims the central bank has on a bank. The vast majority of these claims in normal times are the main refinancing operations. In June 2009, and in December 2011 and March 2012, the ECB conducted long-term refinancing operations with a maturity of one and three years, respectively. These operations are long-term liabilities of banks obtained from the Deutsche Bundesbank.

In addition to our main dependent and independent variables, we use the change from the previous to the current period in the amount of secured liabilities held by a bank, normalized by the total assets of the bank as control variable. We saturate our main regression with period fixed effects to account for changes, for example, in banks' accounting requirements, bank-fixed effects to account for constant cross-sectional heterogeneity, as well as year times bank-fixed effects to capture further unobserved bank-specific time-varying heterogeneity.

3 Descriptive Statistics of the German Interbank Market

We will focus on four stylized facts about the German interbank market during the 2002-2014 period, which helps us to understand its role in the financial system. First, interbank lending accounts for a significant share of an average bank's balance sheet. Second, the network of interbank loans is stable (persistent), even during the financial crisis years. Third, the average contract duration of interbank exposures exceeds one year; overnight exposures are only a fraction of the the overall positions held at any point in time. Fourth, banks tend to hold significant interbank exposures on both sides of the balance sheet,

making them intermediaries among banks. We discuss these stylized facts in turn.

Stylized fact no.1: Interbank lending accounts for a significant share of an average bank's balance sheet. The German interbank market is the largest in the eurozone, and one of the largest worldwide. It is notable not only in terms of its absolute size, but also because interbank lending and borrowing account for a particularly large share of banks' balance sheets in Germany. Figure 1 shows the share of interbank borrowing to total assets for the euro area average, France, the United States, and Germany. Throughout the observation period, the size of the interbank market as measured by the share of interbank lending in total assets is significantly higher in the euro area (18%-21%) than in the US (1%-3%). Among euro area countries, Germany has a relatively large interbank market; its average share in total assets ranges from a high of 48% in 2002 to a low of 32% in 2014. The corresponding values for France, for example, are lower, reaching 20% at the beginning of the period and towards the end, with higher values in between, but are still much higher than the values recorded for the US. The euro area share of interbank borrowing to total assets has been declining slightly since 2002, as has the value for the US. While the figures for Germany have shrunk by more than one-third, they are still higher than the euro area average. The three-pillar structure of the German interbank market, with the commercial bank sector, the cooperative bank sector, and the savings banks sector can only partially explain this very high balance sheet share of interbank borrowing. Figure 7 shows that domestic interbank lending and borrowing by commercial banks accounts for about EUR 150 billion before September 2009, i.e. about 10% of banks' total balance sheet volume, which is still substantially larger than in the US.

If banks were to rely on the interbank market only for short-term liquidity needs, as is suggested by the prevailing view of interbank markets, then the accumulating stock of interbank assets and liabilities should remain moderate and proportional to realized deposit and lending fluctuations. Figure 4 shows the average deposit fluctuations (measured by the yearly standard deviation) relative to the average sum of interbank assets and liabilities (measured by their yearly average), removing 2.5% of the smallest and largest values.

Each point on the graph is based on a window ranging from $t-3$ to t. Banks' interbank assets and liabilities are substantially larger than their average deposit and credit fluctuations. These figures suggest that liquidity considerations relating to stochastic deposit flows alone cannot explain the size of the observed interbank exposures.

Stylized fact no.2: The network of interbank loans is stable (persistent), even during the financial crisis years.

The interbank market is an over-the-counter market and can best be characterized as a network of credit relationships. A network is a set of nodes together with a set of links between these nodes. Being interested in the interbank market, the nodes in our network are banks and the links between them are credit relationships, i.e. interbank loans. One way to quantify how a network changes over time is to compute the Jaccard index of links, which is defined as the number of links that exist in two subsequent periods divided by the number of links that exist in one period only. Figure 2 shows the Jaccard index for the interbank network of all German commercial banks. With a time-averaged Jaccard index of 0.84, the German interbank network is highly stable over our sample period from 2002 to 2014. A further metric for the stability of the network is the unconditional relationship duration. For this, we calculate the fraction of time over the sample period in which there exists a particular lending relationship involving the same two counterparties, given its existence in at least one period. The value is called "unconditional" since it is an average over all contract maturities. This unconditional average over all banks amounts to 0.44, implying its existence for almost half of the sample period. That is, if one bank starts lending to another bank, the duration of that lending relationship lasts for roughly $0.44 \times 43 = 19$ quarters. The long duration of interbank relationships is consistent with the relatively sparse network architecture, which characterizes the German interbank market. Figure 3 shows an index of interconnectedness, defined as the number of existing links relative to the number of possible links, that is, $N_t \times (N_t - 1)$ with N_t the number of banks observed in period t. The index shows that, on average, the network is relatively sparse with only 6% to 11% of the theoretically possible links existing. This is consistent

with a high degree of stability in the German interbank network.

Stylized fact no.3: The average contract duration of interbank exposures exceeds one year; overnight exposures are only one part of the the overall positions held at any point in time.

Figure 7 summarizes the consolidated maturity structure of both sides of the interbank book, the assets side and the liability side. A look at the maturity structure of the German interbank market can help to establish a rationale for all observed stylized facts. We discuss overnight market segments first, then longer term. In our dataset, four disjunct term segments are used on the asset side. A: overnight, B: less than 1 year, C: less than 5 years, D: more than 5 years. There are also four term segments on the liabilities side, although the classifications differ slightly: A: overnight, B: less than 1 year, C': less than 2 years, D': more than 2 years. For the consolidated book of the banking sector, the fraction of overnight interbank lending and borrowing (the A-segment) remains roughly constant at the year-end record dates over the 13-year period 2002-2014. The number oscillates around 4% of the aggregate bank balance sheet volume.

For the B segment, we also find a very similar development peaking in $Q4/2007$ at slightly above 10% (borrowing) and 13% (lending) and then steadily declining until 5% is reached in 2012. The lending graph is above the borrowing graph for most of the sample period. This indicates that, in the relevant term segment, the interbank market is not entirely restricted to Germany, with some net lending to banks in other countries. The international interbank flows are particularly prominent in the years preceding 2008. Thereafter, the wedge between aggregate borrowing and lending reverts to the level at the beginning of the sample.

The size of the maturity segment C with initial contractual terms between 1 year and 5 years, and the corresponding segment C' with contractual terms between 1 year and 2 years, is of the same order of magnitude as the overnight segment. Market segments D and D', including interbank loans with at-issue maturities of more than five (two) years, is

substantial, averaging slightly above 10% of balance sheet size. Here, borrowing exceeds lending over most of the sample period. The wedge amounts to one-tenth of aggregate interbank lending, indicating a net inflow from abroad, i.e. from banking institutions outside our data set. Note that our data do not distinguish between secured and unsecured interbank debentures. In particular since the financial crisis, market participants have repeatedly reported that the unsecured term interbank market plays almost no role for their refinancing and that most of interbank lending is only secured.

Stylized fact no.4: Banks tend to hold significant interbank exposures on both sides of the balance sheet, making them intermediaries among banks.

The fourth stylized fact refers to the extent to which there is interbank intermediation in the market.

Figure 8 shows an estimate of interbank intermediation, the fraction of banks which have, at the same time, significant interbank exposures on both sides of their balance sheet, assets and liabilities. Exposures are defined as being significant in volume if, at a given point in time, the amount of interbank assets is larger than 25% of the amount of interbank liabilities, while, at the same time, the amount of interbank liabilities is larger than 25% of the amount of interbank assets. On average, over 75% of all banks hold significant interbank positions simultaneously in any given year between 2002 and 2014. The range of variation is less than 5 pecentage points over most of the sample period. Between mid-2007 and early 2009, the height of the financial crisis, the interbank intermediation index rises above 80%. Thus, and in contrast to the widely held view of a frozen interbank market, we find an increase in reliance on intermediation among banks, as defined by simultaneous holdings of gross interbank exposures. The index falls back to its earlier level of around 75% in early 2009 and stays at that level for the remaining years. What can be observed, though, is that the intermediation index for the term interbank market decreases continuously, by over 15 percentage points between September 2008 and December 2014.

In Figure 10 the sum of gross exposures vis-à-vis banks on both sides of the balance sheet is related to their difference, i.e. net exposure. Sums are taken without regard to the identity of counterparties, i.e. netting is allowed within the balance sheet position even if the identity of counterparties is not necessarily the same. This is because we want to estimate the extent to which there is significant concurrent exposure on both sides of the balance sheet. We label the ratio of gross interbank exposure to net interbank exposure the *'funding gap'*. For example, if a bank borrows large amounts from another bank and uses the funds for granting new loans rather than intermedition to other banks, the resulting interbank funding gap is large (well above +1). Similarly, if the bank uses funds from its deposit business for which is has no suitable loan demand for intermediation to some other bank, the gap variable will once again be a high positive number, well above +1. If, however, most of the funds lent to banks were funded by borrowing from other banks, the funding gap is small. In the limit, when both positions are equal, the gap variable approaches 0.

4 Hypotheses and Empirical Strategy

The observations reported in the previous section suggest that there is intermediation in the interbank market. Banks lend to banks and borrow from banks simultaneously, and do so persistently. This is not easy to reconcile with a pure short-term liquidity insurance view of interbank markets, which posits that the interbank overnight market is predominantly used to buffer (i.e. go long or short) fluctuations in the cash account. No longer term interbank exposures are needed in this case, nor is there a rationale for entering into long and short interbank position simultaneously.

Ultimately, a theory of the interbank market as an integral part of the finanial intermediation process is needed. The question to be answered is: *"What role does the intermediation among intermediaries play in bridging the informational and preferential funding gap between households (as ultimate lenders) and firms (as ultimate borrowers)?"* Here,

informational gaps refer to asymmetric information and moral hazard, and preferential gaps refer to liquidity and safety preferences. Banking theory in the spirit of Diamond (1984) and Diamond and Rajan (2001) does not have much to say about second-level financial intermediation. Even if the interbank market is explicitly considered, as in Allen and Gale (2000), and in Freixas and Jorge (2008), longer-term interbank relationships are difficult to explain. Further attempts to consider interbank markets can be found in Rochet and Tirole (1996), Afonso et al. (2013), and Acharya and Skeie (2011). The first explicit attempt to model interbank intermediation, commensurate with what we observe in the German interbank market, is John Moore's Presidential Address at the Econometric Society in 2011 (Moore (2011)). He models a two-level intermediation process, called leverage stacks, in which longer-term interbank relationships create a peer monitoring mechanism that allows uninformed depositors to trust in the screening and monitoring capabilities of 'their' bank. In Moore's model, this mechanism permits an efficient channeling of funds from households to entrepreneurs.

Moore's model is consistent with many of our stylized facts. In particular, it supports the existence of an interbank book on top of the usual client book held by a bank. It also explains why interbank relationships are large in absolute and relative terms, why they are persistent, and why they gross-up on both sides of the balance sheet rather than being netted continuously. However, what the leverage stacks model does not yet capture is the importance of term structure characteristics we have identified in the data. In other words, the large share of longer-term exposures in the interbank intermediation mechanics still needs explanation.

We want to advance the hypothesis that the interbank market is used by banks to manage the duration gap inherent in their client book.

Recall that the client book comprises the whole of loans outstanding, and deposits intake to/from customers (households and non-bank corporates). These exposures are autonomous from the point of view of the bank, because they are generated by independent decisions of third parties. Households, for example, allocate their cash to bank

accounts at their own discretion concerning timing (now or later) and term (overnight deposit or long-term bond). The resulting balance sheet aggregates can be described by their weighted average contract length, called *'duration'* (see Weil (1973)). The difference of asset duration minus liabilities duration is the *'duration gap'*, or *'duration risk'*; it captures the sensitivity of bank equity capital to a shift of the term structure of interest rates. In Hellwig (1994), the duration gap is widely seen as describing the main interest rate risk of banks. Thus, duration risk stemming from the client book is largely exogenous to the bank. However, the duration risk stemming from the interbank book is fully endogenous, i.e. the portfolio to assets and liabilities in the interbank book, and their respective maturities are, by and large, autonomously set by bank management.

Think of the interbank market as a common resource to which to lend when there is an unexpectedly large deposit inflow, and from which to borrow when there is an unexpectedly large credit draw-down. By carefully selecting the maturities for these derived (endogenous) transactions with other banks, the bank regains some autonomy over its duration risk. To give an extreme example, consider a bank with exogenous changes of its assets (credit draw-downs in the client book) and equally exogenous changes of its liabilities (deposits in the client book). If the bank chooses to offset each autonomous change of exposure with an offsetting transaction of equal size and equal maturity in the interbank market, then, effectively, the client book is augmented by an interbank book that is an exact mirror image of the underlying client book. In this case, duration risk is zero.

In reality, several other considerations will be relevant for bank management when the duration gap of the interbank book is determined - however, we expect to find a tendency to lower the duration risk inherent in the client book. In our view, the client book is autonomous and the interbank book is a derivative book - derivative to the client book.

The duration gap is an important variable not only for bank risk management and profit optimization, but also for macroeconomic risks and macroprudential policies. Based on the stylized facts, and the theory outlined above, we derive several hypotheses to be

tested empirically.

Hypothesis 1 (Interbank exposures): At the bank level, total innovations in (changes of) net interbank exposure, after netting assets and liabilities, are driven by concurrent underlying client business (the client book).

The client book in Hypothesis 1 refers to retail and wholesale non-bank lending and deposit taking. The hypothesis states that transactions with the classical bank clients, households and firms, can explain, at least partially, the changes observed concurrently in the bank's interbank accounts (i.e., its interbank book).

Hypothesis 2 (Interbank maturities): At the bank level, innovations in interbank assets and interbank liabilities are driven by underlying client business, primarily in the same maturity bucket.

The idea behind Hypothesis 2 is the management of bank duration risk. Assuming the changes in the bank's client book to be largely autonomous from the point of view of the bank, it can respond to undesired changes in its duration gap by constructing offsetting transactions in the interbank book. This solves, at the same time, its desire for efficient use of funds (minimizing storing liquidity reserves as idle funds) and its desire for controlling its overall duration risk. The fact that we do not know the bank's target duration risk is also the reason why the hypothesis refers to the same maturity bucket as a primary, but not the sole, determinant of interbank lending decisions.

Hypothesis 3 (Interbank exposure accumulation): The interbank book, consisting of borrowing and lending positions, grows over time by accumulating gross interbank exposures vis-à-vis counterparties rather than netting exposures.

Hypothesis 3 focuses on the dynamics of the interbank book. It claims that autonomous transactions in the client book trigger (to some extent, see Hypothesis 2) an offsetting of transactions in the interbank book on a transaction-by-transaction basis. Netting positions vis-à-vis the same counterparty, and/or within the same maturity bucket would

be feasible, say by recontracting, but this will not be done. The reason can be found in the primary objective of the interbank book in providing low-cost access to liquid resources (i.e. being able to serve their retail and corporate clients at once), while simultaneously managing the overall duration risk that has to be borne by the bank's owners.

Hypotheses 1-3 establish the most important characteristics of interbank intermediation: large exposures on both sides of the balance sheet of a majority of banks, the dynamics of which are driven by the underlying client business, i.e. autonomous inflows and outflows from business relations with retail and non-bank corporate customers. The resulting pattern *"stacks"* an interbank book on top of the underlying client book. The combined client plus interbank book achieves (or helps to achieve) a bank's desired duration risk.

The mechanics of this interbank intermediation system is of interest not only from a bank management viewpoint, but also from a macroeconomic policy perspective. Several questions suggest themselves. For example, what are the implications of interbank intermediation for the efficient allocation of funds in the economy? What implications does interbank intermediation have for effectiveness of monetary policy? And, perhaps most importantly, what are the possible consequences for financial stabilty? We will defer these and other questions for a follow-up paper, and wish now to limit our macroeconomic perspective to an issue that is implicit in much of the descriptives already presented and discussed in Section 2: the changing dimension and working of the interbank intermediation model during the crisis years. For this purpose, we will distinguish between the first half of our data set, the pre-Lehman years 2002-2008, and the crisis years post-Lehman (2008-2014).

Hypothesis 4 (Interbank intermediation pre- and post-Lehman): Abundant central bank liquidity supply serves as a partial substitute for the interbank market.

The argument leading to Hypothesis 4 relies on the double role of the interbank market in serving as a mutual liquidity reservoir for all banks in the system, and, at the same time, as a tool for managing the duration risk. The former role can be substituted by

cheap and abundant central bank liquidity provision.

To test H1, which conjectures that overall innovations in interbank exposure are driven by concurrent underlying client business, we estimate Equation (1)

$$\frac{\Delta(\text{Net Interbank Lending})_{it}}{\text{Assets}_{i,t-1}} = \sum_{j=0}^{12} \alpha_j \frac{\Delta\text{Deposits}_{i,t-j}}{\text{Assets}_{i,t-j-1}} + \sum_{j=0}^{12} \beta_j \frac{\Delta\text{Loans}_{i,t-j}}{\text{Assets}_{i,t-j-1}} + \text{Controls} + \beta_i + \beta_t + \beta_{iT} + \epsilon_{it} \quad (1)$$

where all variables are aggregates across all maturities. For example, the explanatory variable 'Loans' which captures bank credit to the real economy includes all loans up to one year (which is the shortest available maturity for the variable in our data set) and beyond. Our hypothesis is confirmed if we find a statistically significant and positive coefficient of the change in deposits (relative to total assets), α_0, and a statistically significant negative coefficient of the change in the loan supply (relative to total assets), β_0. We explicitly control for the amount of secured liabilities, but we control for most unobserved heterogeneity through fixed effects. In addition to period fixed-effects, which capture time trends and changes in reporting standards (e.g. the *Act Modernising Accounting Law* in December 2010), we saturate our regressions with bank-fixed effects, and ultimately by using bank times year-fixed effects to control for any unobserved heterogeneity at the bank level.

Note that an important underlying assumption is that loans and deposits are contemporaneously exogenous with respect to banks' interbank lending and borrowing. First, deposit fluctuations depend largely on customers' preferences and are therefore outside the control of the bank (though they can be influenced in the long run, for example through an advertising campaign or by setting up a larger branch network). Second, loans are jointly determined by demand and supply, that is, the variable is partially controlled by the bank. However, when banks grant a loan, they create money 'ex nihilo', that is, they create the deposits that are subsequently used by the customer. It is only when the customer draws on the deposits that the bank faces an outflow of liquidity which it

eventually has to replace. Therefore, loan creation takes place before any liquidity shock can occur. If a bank wants to grant a profitable loan, but fears that it cannot refinance subsequent liquidity outflows on the interbank market, it can always turn to the central bank's (frequent) main refinancing facility (such as the ECB's weekly tender). Therefore, we argue that reverse causality issues do not arise in our regressions. In any case, all our results are robust across specifications in which only lags of the explanatory variables are used.

To test our second hypothesis, which conjectures that innovations in net interbank exposure are driven by underlying client business, primarily in the same maturity bucket, we extend Equation (1) by a maturity dimension. Testing for the hypothesis in the overnight segment is then carried out via estimating Equation (2)

$$\begin{aligned}\frac{\Delta(\text{Net Interbank Lending})^{ST}_{it}}{\text{Assets}_{i,t-1}} = & \sum_{j=0}^{12}\alpha_j\frac{\Delta\text{Deposits}^{ST}_{i,t-j}}{\text{Assets}_{i,t-j-1}}+\sum_{j=0}^{12}\beta_j\frac{\Delta\text{Loans}^{ST}_{i,t-j}}{\text{Assets}_{i,t-j-1}} \\ & \sum_{j=0}^{12}\gamma_j\frac{\Delta\text{Deposits}^{LT}_{i,t-j}}{\text{Assets}_{i,t-j-1}}+\sum_{j=0}^{12}\delta_j\frac{\Delta\text{Loans}^{LT}_{i,t-j}}{\text{Assets}_{i,t-j-1}} \\ & +\text{Controls}+\beta_i+\beta_t+\beta_{iT}+\epsilon_{it} \qquad (2)\end{aligned}$$

where variables are defined as previously and ST and LT denote short-term (overnight) and longer-term (>overnight), respectively. Our hypothesis is confirmed if in Equation (2) we find the coefficient of (i) changes in overnight deposits, α_0, significantly positive and (ii) bigger than that of changes in longer-term deposits, γ_0, as well as (iii) changes in short-term loans, β_0, significantly negative and (iv) smaller than that of changes in long-term loans, δ_0.

Testing for our second hypothesis in the longer-term segment is carried out with Equation

(3):

$$\begin{aligned}\frac{\Delta(\text{Net Interbank Lending})_{it}^{LT}}{\text{Assets}_{i,t-1}} &= \sum_{j=0}^{12}\alpha_j\frac{\Delta\text{Deposits}_{i,t-j}^{ST}}{\text{Assets}_{i,t-j-1}}+\sum_{j=0}^{12}\beta_j\frac{\Delta\text{Loans}_{i,t-j}^{ST}}{\text{Assets}_{i,t-j-1}} \\ &\quad \sum_{j=0}^{12}\gamma_j\frac{\Delta\text{Deposits}_{i,t-j}^{LT}}{\text{Assets}_{i,t-j-1}}+\sum_{j=0}^{12}\delta_j\frac{\Delta\text{Loans}_{i,t-j}^{LT}}{\text{Assets}_{i,t-j-1}} \\ &\quad +\text{Controls}+\beta_i+\beta_t+\beta_{iT}+\epsilon_{it} \qquad (3)\end{aligned}$$

where only the dependent variable has been replaced with respect to Equation (2). Our hypothesis is confirmed if in Equation (3) we find the coefficient of (i) changes in longer-term deposits, γ_0, significantly positive and (ii) bigger than that of changes in overnight deposits, α_0, as well as (iii) changes in long-term loans, δ_0, significantly negative and (iv) smaller than that of changes in short-term loans, β_0.

To test our third hypothesis, which conjectures that the interbank book grows over time by accumulating gross interbank exposures towards counterparties rather than netting with extant exposures, we estimate Equations (4) and (5) given below.

$$\begin{aligned}\frac{\Delta(\text{Gross Interbank Assets})_{it}^{LT}}{\text{Assets}_{i,t-1}} &= \sum_{j=0}^{12}\alpha_j\frac{\Delta\text{Deposits}_{i,t-j}^{LT}}{\text{Assets}_{i,t-j-1}}+\sum_{j=0}^{12}\beta_j\frac{\Delta\text{Loans}_{i,t-j}^{LT}}{\text{Assets}_{i,t-j-1}} \\ &\quad +\text{Controls}+\beta_i+\beta_t+\beta_{iT}+\epsilon_{it} \qquad (4)\end{aligned}$$

$$\begin{aligned}\frac{\Delta(\text{Gross Interbank Liabilities})_{it}^{LT}}{\text{Assets}_{i,t-1}} &= \sum_{j=0}^{12}\gamma_j\frac{\Delta\text{Deposits}_{i,t-j}^{LT}}{\text{Assets}_{i,t-j-1}}+\sum_{j=0}^{12}\delta_j\frac{\Delta\text{Loans}_{i,t-j}^{LT}}{\text{Assets}_{i,t-j-1}} \\ &\quad +\text{Controls}+\beta_i+\beta_t+\beta_{iT}+\epsilon_{it} \qquad (5)\end{aligned}$$

where the dependent variables are now defined in individual gross terms as opposed to their joint net terms in previous regressions and, to save space, the main short-term explanatory variables are included in our set of control variables. Note that our previous regressions to test Hypotheses 1 and 2 cannot by construction provide conclusive evidence in favor or against this hypothesis. For example, as will become clear below, an increase in the long-term loan supply results in a decreasing net longer-term liquidity supply to the

interbank market. However, this reduction can be due either to (i) increased borrowing on the interbank market (which, as conjectured by our third hypothesis, leads to an increase of the interbank book), (ii) a reduction of interbank lending (which leads to a decrease in gross exposures), or (iii) both. Note that we focus only on the longer-term segments here, because frequent lending and borrowing at long maturities can provide an explanation for the gross interbank position being bigger than the net interbank position if banks –instead of canceling extant interbank positions– take on offsetting interbank positions. By contrast, in the overnight segment it is always possible to not roll over extant positions, resulting in less scope for building up larger gross positions than net ones. Extending the above example, a bank featuring a longer-term deposit inflow could absorb this shock to its balance sheet either by increasing its longer-term liquidity supply to the interbank market (its bank book grows) or by canceling an extant longer-term interbank borrowing relation (its bank book shrinks).

We find evidence to support our third hypothesis if (i) the effect of changes in longer-term deposits on gross longer-term interbank assets, α_0, is significantly positive and, (ii) bigger than the effect of changes in longer-term deposits on the change in gross longer-term interbank liabilities, γ_0, and if, (iii) the effect of long-term loans on gross longer-term interbank liabilities, δ_0, is significantly negative and, (iv) smaller than the effect of changes in long-term loans on the change in gross longer-term interbank assets, β_0. Note that testing Hypothesis 3 requires testing linear restrictions involving parameter estimates from Equations 4 and 5. Both equations therefore are estimated in a seemingly unrelated regressions framework.

To test our fourth hypothesis, which conjectures that central bank liquidity serves as partial substitute for the interbank market, we compare coefficient estimates in our regressions in a sample of data prior to the recent financial crisis and a sample which features the financial crisis and period with abundant central bank liquidity support. Our fourth hypothesis is confirmed if coefficients are systematically smaller in absolute value in our sample comprising the financial crisis.

5 Results

To test our four hypotheses we run three sets of regressions. In all following analyses the Chow breakpoint test indicates a structural break in October 2008. Therefore, we split our sample regressions into three data sets, a full set covering February 2002 to December 2014, a subset covering February 2002 to September 2008, and another subset covering October 2008 to December 2014. Quite naturally, the sample has a pre-Lehman portion which is covered in the first subset and a post-Lehman portion featuring the acute phases of the financial and (European) sovereign debt crises, which are in the second subset. We conjecture that, in the former period, the interbank market operates under 'normal' conditions–although we know that years running up to the crisis are special as well–while in the latter period the interbank market operates under 'crisis' conditions, not least indicated by the non-standard central bank interventions taking place during that period. For investigating our first three hypotheses, we concentrate on the 'normal' sample, while, for analyzing our fourth hypothesis, we compare results from our 'normal' and 'crisis' samples. Note that we also provide estimation results over the full sample in all analyses.

To investigate if banks' net liquidity supply to the interbank market is driven by client business (Hypothesis 1), we estimate Equation (1). Remember that confirmation of H1 requires α_0 to be positive and β_0 to be negative (tested individually). Estimation results are displayed in Table 1, which is subdivided into results obtained from our full sample, the 'normal' sample, and the 'crisis' sample. For each sample we run three specifications, which include different sets of dummy variables in addition to our main explanatory variables (changes in banks' deposit and loan business), and a set of further controls (changes in securitized liabilities as well as central bank assets and liabilities): specifications 1, 4, and 7 feature bank-fixed effects, specifications 2, 5, and 8 feature bank and month-fixed effects, and specifications 3, 6, and 9 feature bank, month and bank-year fixed effects.

First we concentrate on estimation results from the 'normal' sample (models 4 to 6 on Table 1). Note that, in all following regressions, we concentrate only on contemporaneous regressors, because their effects are much bigger than those of the lagged regressors. Furthermore, lagged effects, generally feature the same sign as the contemporaneous effects, but mostly turn insignificant after more than three lags. In all three specifications, an increase in the loan supply (relative to total assets) by 1 percentage point decreases the net interbank supply (relative to total assets) by about 0.91 (model 4) to 0.93 (model 6) percentage points (rounded to two decimal places). That is, faced with liquidity outflows subsequent to assigning new loans to the real economy results in less net interbank lending (or equivalently, more net interbank borrowing). Note that effects are statistically significant at the 1% significance level. Furthermore, an increase in deposits by 1 percentage point increases net interbank lending by 0.91 percentage points. Effects are statistically significant at the 1% significance level. These results show that banks facing liquidity inflows react by channeling part of these funds to the interbank market. The model fit is generally quite good – the adjusted R^2 ranges from 0.83 (model 5) to 0.84 (models 4 and 6).

Note that our findings remain robust when we focus on the 'full' sample (models 1 to 3), though remember that it contains a structural break. This is also reflected in a decreasing adjusted R^2 by about 7 percentage points. Overall, our results provide strong evidence in favor of our first hypothesis. Banks' client business is indeed an important driver of banks' net liquidity supply to the interbank market. Note that results turn out robust across model specifications. In the following sets of regressions we concentrate only on a specification with the full set of dummies.

To investigate if innovations in interbank assets and liabilities by maturity bracket are driven by underlying client business in the same maturity bracket (Hypothesis 2), we estimate Equations (2) and (3) with the former featuring net overnight interbank lending and the latter net longer-term (with a maturity beyond overnight) interbank lending, respectively. Both configurations feature banks short and longer-term client businesses

as explanatory variables and a set of further control variables and dummies. Recall that overnight deposits and loans feature a maturity of overnight and up to one year, respectively, while longer-term deposits and loans feature a maturity beyond these respective short-term values. Differences in maturity brackets are primarily determined by the data set's partition.

First, consider the overnight segment of the interbank market. Remember that for Equation (2) confirmation of H2 requires obtaining a coefficient of (i) changes in overnight deposits, α_0, significantly positive and (ii) bigger than that of changes in longer-term deposits, γ_0, as well as (iii) changes in short-term loans, β_0, significantly negative and (iv) smaller than that of changes in long-term loans, δ_0. Note that, here and below, we carry out tests for linear combinations of coefficient estimates using one-sided z-tests.

Table 2 displays estimation results for Equation (2). Note that we include the change in net longer-term interbank lending as an additional control variable in order to capture substitution effects between longer-term and overnight interbank segments. In the normal sample (model 2) an increase in short-term or long-term loans by 1 percentage point significantly decreases banks' net overnight interbank lending by 0.71 or 0.70 percentage points, respectively. The effect of short-term loans is not significantly bigger (in absolute terms) than that of long-term loans (p-value of 0.12 indicates only marginal significance). An increase in short or longer-term deposits by 1 percentage point significantly increases net overnight interbank lending by 0.80 or 0.66 percentage points, respectively. The effect of overnight deposits is significantly stronger than that of longer-term deposits (p-value of 0.05). Notice that an adjusted R^2 of 0.76 indicates a good model fit. Overall, we find some statistical evidence in favor of our hypothesis for the overnight interbank market, in particular as regards effects of overnight deposits.

Second, consider investigating H2 for the longer-term segment of the interbank market. Remember that for Equation (3), confirmation of H2 requires the coefficient of (i) changes in longer-term deposits, γ_0, to be significantly positive and (ii) bigger than that of changes in overnight deposits, α_0, as well as (iii) changes in long-term loans, δ_0, to be significantly

negative and (iv) smaller than that of changes in short-term loans, β_0. Note that we include the change in net overnight interbank lending as an additional control variable in order to capture substitution effects between long and overnight interbank lending and borrowing.

Table 3 displays estimation results for Equation (3). In the 'normal' sample (model 2) an increase in long-term loans by 1 percentage point decreases net longer-term liquidity supply to the interbank market by 0.84 percentage points, while an increase in longer-term deposits increases the longer-term net liquidity supply to the interbank market by 0.49 percentage points. Effects are significant at the 1% significance level. Note that both changes in overnight deposits and loans also yield significant results (at the 1% level) featuring the expected sign. For example, an increase in overnight deposits by 1 percentage point increases the net longer-term liquidity supply to the interbank market by 0.49 percentage points. This provides evidence that banks with overnight liquidity inflows carry out some maturity transformation. Furthermore, an increase in short-term loans by 1 percentage point lowers the net longer-term liquidity supply to the interbank market by 0.29 percentage points. Note that, while we find a significantly bigger coefficient in absolute value for the long-term loan variable than for the short-run loan variable (p-value of 0.00), the coefficients for the deposit variable are of similar magnitude and not significantly different. Therefore, we also find partial evidence in favor of our second hypothesis, in particular as regards banks' client loan business. The effect of innovations in net overnight interbank lending indicates that the short and longer-term segments of the interbank market are, to some extent, substitutes –an increase in net overnight interbank lending by 1 percentage point causes a decline in net longer-term interbank lending of 0.23 percentage points. The adjusted R^2 of 0.58 indicates a good model fit. All results are also robust in the full sample (model 1).

In conjunction, results on Tables 3 and 2 adduce evidence that changes in net short and longer-term interbank lending are driven by client business in the same maturity bracket. Furthermore, client business from different maturity brackets also features economical

and statistical significance and can be explained by banks' maturity transformation.

Our third hypothesis conjectures that the interbank book grows over time via the accumulation of longer-term interbank positions on both sides of the balance sheet driven by banks longer-term client business. Remember that our third hypothesis is confirmed if (i) the effect of changes in longer-term deposits on gross longer-term interbank assets, α_0, is significantly positive and, (ii) bigger than the effect of changes in deposits on the change in gross longer-term interbank liabilities, γ_0, and if, (iii) the effect of long-term loans on gross longer-term interbank liabilities, δ_0, is significantly negative and, (iv) smaller than the effect of loans on the change in gross longer-term interbank assets β_0.

Tables 4 and 5 display estimation results for Equations (4) and (5), respectively. Both equations are jointly estimated in a seemingly unrelated regressions framework in order to carry out linear hypothesis tests across equations. To verify if H3 is confirmed, we again focus on the normal sample, that is, model 2 in both tables. First, consider the effect of changes in long-term loans on gross longer-term interbank assets. In Table 4 the effect is insignificant. However,changes in short-term loans which feature a maturity of up to one year are significantly negative. An increase in short-term loans by 1 percentage point lowers gross longer-term interbank assets by 0.45 percentage points. In Table 5 (featuring results for changes in gross longer-term interbank liabilities as the dependent variable) the effect of changes in long-term loans is significant and of (expected) positive sign. An increase in long-term loans by 1 percentage point results in an increase in gross longer-term interbank liabilities of 0.84 percentage points. Also here, short-term loans are significant and of expected positive sign but much smaller magnitude. An increase in short-term loans by one percentage point results in an increase of gross longer-term interbank liabilities by 0.05 perceantage points. Importantly, the effect of long-term loans on gross longer-term interbank liabilities (Table 5) is significantly bigger in absolute value (p-value of 0.00) than its effect on gross longer-term interbank assets (Table 4), providing confirmation of our third hypothesis.

Next, consider the effect of changes in longer-term deposits on banks' gross longer-term

interbank assets. In Table 4, model 2, the effect is significantly positive. An increase in longer-term deposits by 1 percentage point results in an increase in gross longer-term interbank assets of 0.35 percentage points. Changes in overnight deposits feature a stronger effect (0.53), indicating that banks carry out some maturity transformation. In both cases effects are of expected sign and significant at the 1% significance level. In Table 5 (change in gross longer-term interbank liabilities), the effect of changes in longer-term deposits is also significant and of expected (negative) sign. An increase in longer-term deposits by 1 percentage point leads to a decline in gross longer-term interbank liabilities of 0.10 percentage points. Note that here, too, we find confirmation of our third hypothesis, that is, the effect of an increase in longer-term deposits on building up new interbank exposures (gross longer-term interbank assets) is significantly larger in absolute value (p-value of 0.00) than the effect of reducing extant positions (gross longer-term interbank liabilities).

In conjunction, results from Tables 4 and 5 provide evidence in favor of our third hypothesis. That is, in the face of positive innovations in their longer-term client book, banks increase their bank book, resulting in bigger gross interbank positions than net ones. Note however, that results in both tables also indicate that banks do not exclusively build up new interbank positions to buffer shocks, but also reduce extant exposures, possibly not rolling over maturing debt positions.

Finally, to investigate our fourth hypothesis, which conjectures that abundant central bank liquidity serves as partial substitute for the interbank market, we compare our previous estimation results from the 'normal' sample with those of the 'crisis' sample. Remember that the sample split is found by a Chow test, indicating a statistical break during the Lehman bankruptcy. That is, there is already statistical evidence for a regime change of the interbank market with the onset of the financial crisis.

First, consider both samples on Table 1 and remember that this table provides results for our estimations on banks' change in net interbank lending as a function of innovations in their client business. For all three specifications, the magnitude of effects is significantly

bigger in the 'normal sample' (by roughly 20 %) for both loan and deposit innovations (p-values less than 0.05). For example, while an increase in loans by 1 percentage point leads to a decrease of net interbank lending by 0.93 percentage points in our normal sample (model 6), the same change in the explanatory variable leads only to a decline in net interbank lending of 0.78 percentage points during our 'crisis' sample (model 9). Second, consider Table 2, which gives results for explaining changes in net overnight interbank lending by banks' client business in different maturity segments. For both, changes in deposits and loans in both maturity segments the effects become significantly weaker (p-values less than 0.01) in the 'crisis' sample (the effects of changes in short and long-term loans are reduced by about 60% and 70%, respectively, and the effects of short and longer-term deposits are reduced by more than 50%). Third, the same picture emerges when investigating differences between effects in Table 3, which gives results for the change in net longer-term interbank lending explained by changes in different maturity segments of banks' client business. It also confirms that the magnitude of effects significantly shrinks in the 'crisis' sample (p-values below 0.05). While the effects of innovations in short and longer-term deposits shrink by more than 50%, the effect of changes in short-term loan innovations is reduced by roughly 30%, and the effect of changes in long-term loans vanishes almost entirely. Fourth, consider Tables 4 and 5, which explain banks' changes in longer-term interbank assets and interbank liabilities, respectively, using banks' short-term and longer-term client business. Here, too, effects become significantly smaller (in absolute value) except for the effect of long-term loans on longer-term interbank assets (Equation 4, estimation results displayed on Table 4), which is insignificantly different from zero in the normal and the crisis samples. The effect of longer-term deposits on banks' gross longer-term interbank assets shrinks by about 50%. The coefficient in the normal sample is significantly bigger with a p-value of 0.01. Note that the effect of short-term loans on gross interbank assets is also significantly bigger in absolute value during the normal sample (p-value of 0.05) relative to the crisis sample. The coefficient shrinks by about 50%.

On Table 5, the effects of both long-term loans and deposits are significantly bigger (in

absolute value) relative to the crisis sample (p-value of 0.05). The magnitude of effects of long-term loans shrinks by about 95% and that of longer-term deposits by about 60%.

Overall, in all regressions, the role of the interbank market as a liquidity reservoir and risk management tool becomes significantly smaller during the 'crisis' sample which features abundant central bank liquidity that might have partly substituted the role of the interbank market. Therefore, our results provide evidence in favor of our fourth hypothesis of a diminished role of the interbank market with the onset of the financial crisis and central banks' non-standard monetary policies.

6 Conclusion

Using a complete data set of interbank exposures among German banks over the 2002-2014 period, we discover several features of interbank relationships that were not well known before. First, interbank exposures are a significant part of bank assets, averaging 20-25 %. Second, interbank exposures are not only of a short-term nature, as was widely believed. Rather, we find these exposures to have an average maturity of at least 1 year. This number is actually likely significantly larger, as our numerical estimate builds on the maturity buckets reported in banking statistics, and are thus the lower bound of the true estimate. Third, most institutions have significant exposures vis-à-vis other banks on both sides of the balance sheet - and thus become intermediaries among banks. We have labeled this property interbank intermediation, to distinguish it from the more direct and well-understood bank intermediation. The latter connects households and firms, while the former connects banks and banks. Accountingwise, these exposures are recorded in a client book and an interbank book, respectively. Fourth, we find interbank intermediation, as recorded in the interbank book, to be derivative to the bank's client book. The autonomous transactions of bank clients (households and firms) determine the build-up of the interbank book. We find evidence that banks arrange the term structure of the interbank book such that it reflects the inverse of the client book, i.e. a overnight

deposit triggers an equally overnight interbank lending, while a long-term loan to non-bank clients triggers an equally longer-term interbank funding transaction.

Thus, the interbank book grows in parallel to the (autonomous) client book, and resembles, to some extent, its mirror image. The interbank book is a policy instrument of the bank, and it can be –and effectively is- used to manage the overall interest risk embedded in maturity differences between a bank's assets and its liabilities. Our data suggest that banks tend to lower this maturity difference, the so-called duration gap, and thus utilize the interbank market to spread duration risk across banks. Fifth, and last, we look at the interbank market in stress periods by comparing its operation pre- and post-Lehman, i.e. over the subperiods 2002-2008 and 2008-2014. In the latter subperiod, we have a much stronger role of the central bank as a supplier of cheap liquidity to banks, through its full allottment program in 2011, and its LTRO 1 and 2 facilities in subsequent years. Our analysis reveals that the stronger role of central bank liquidity supply in the post-Lehman era has significantly affected the role of the interbank market.

Appendix

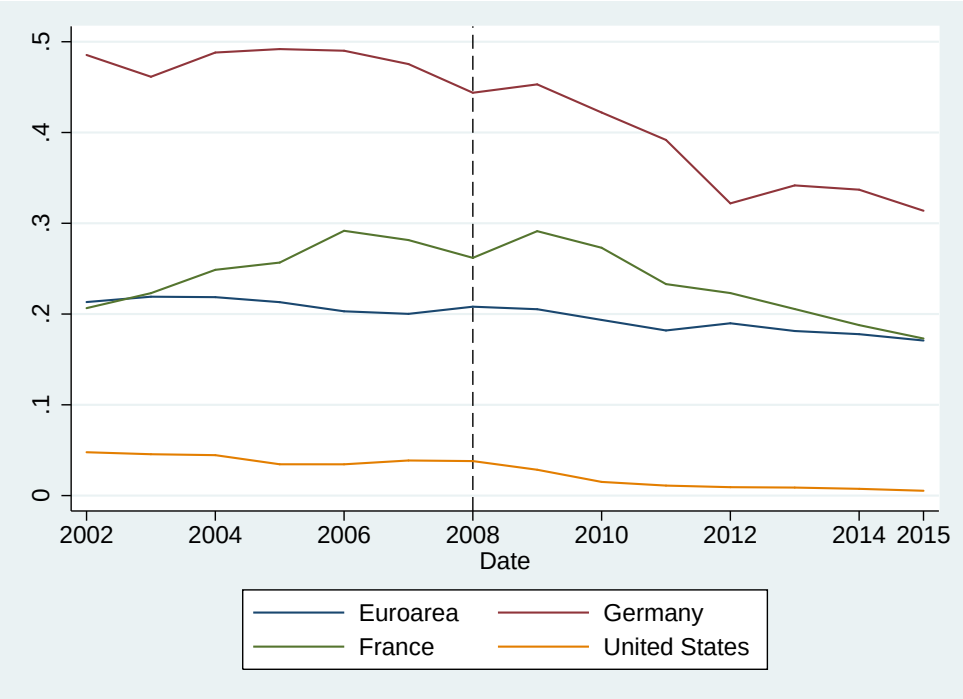

Figure 1: Average share of interbank lending to total asset size for different countries and the euro area. Interbank lending includes all maturities and the fraction is computed for the entire banking system in the respective regions, i.e. including savings and cooperative banks. Sources: ECB Data Warehouse and the Federal Reserve System.

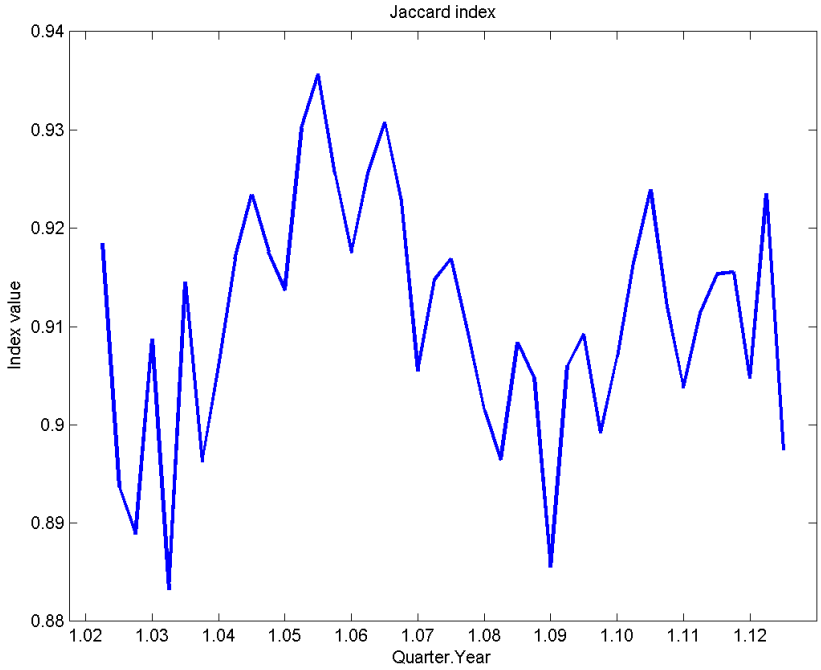

Figure 2: Jaccard index for the entire German banking system (i.e. including savings and cooperative banks). The Jaccard index is defined as the fraction of lending relationships that exist in two subsequent quarters divided by the total number of lending relationships.

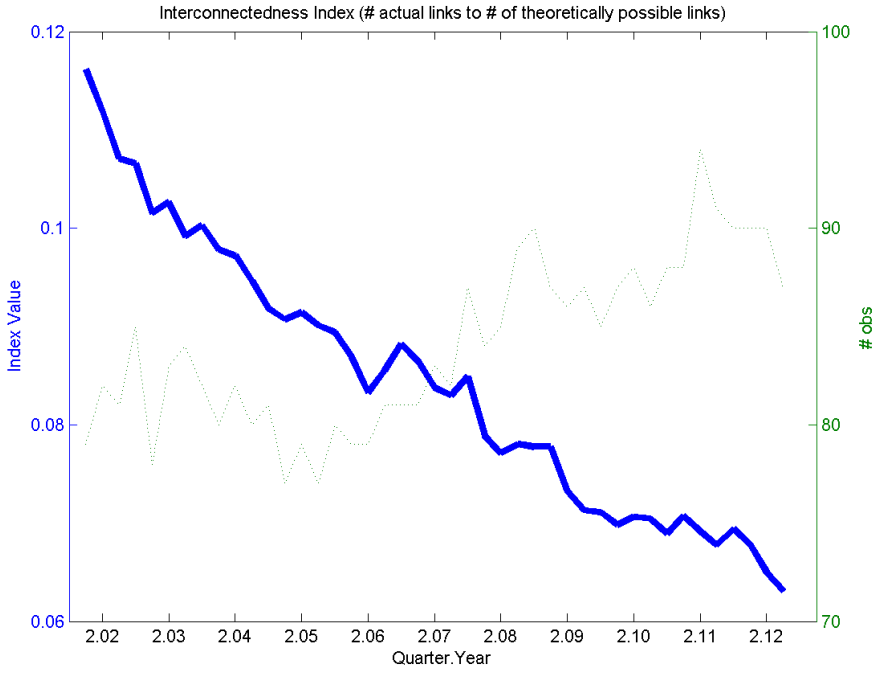

Figure 3: Interconnectedness index for the German commercial banking sector (i.e. excluding savings and cooperative banks) defined as the fraction of possible interbank links that actually exist (blue line, left vertical axis). The number of banks observed at a given point in time is displayed by the green line (right vertical axis).

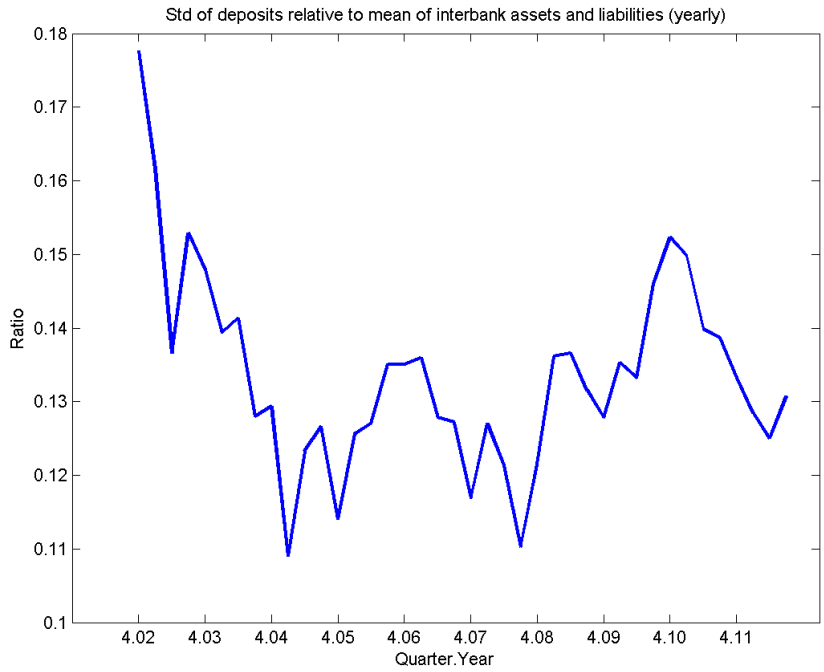

Figure 4: The figure shows the average deposit fluctuations (measured by the yearly standard deviation) relative to the average sum of interbank assets and liabilities (measured by their yearly average), removing 2.5% of the smallest and largest values. Each point on the graph is based on a window ranging from $t-3$ to t

Figure 5: Total asset size of the German commercial banking system. The first horizontal dashed line is in September 2008, the second in June 2009, and the third in December 2011.Values are in billion Euro.

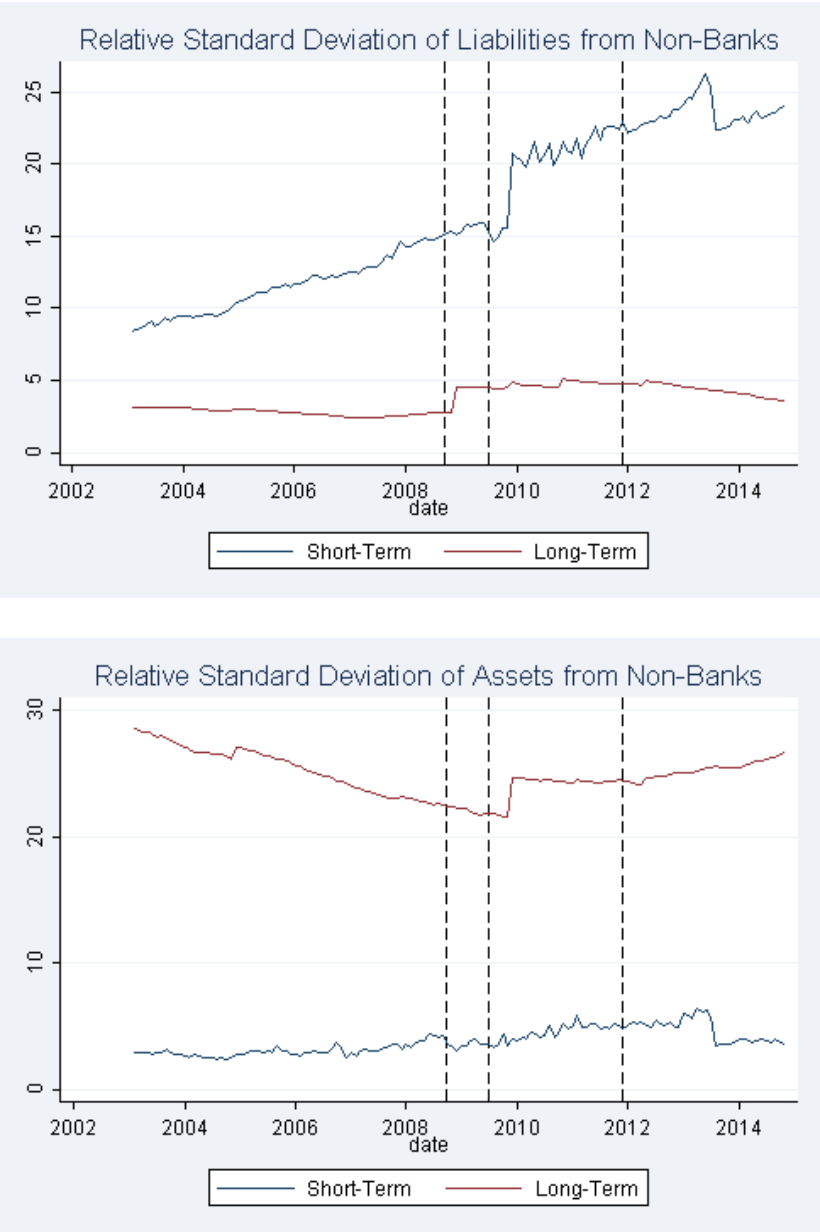

Figure 6: Relative standard deviation of liabilities and assets from non-banks. The relative standard deviation is the standard deviation of deposit and loan fluctuations at a given date (across all banks), divided by the mean of deposits and loans at that date. Short-term (long-term) liabilities are overnight (have a maturity of longer than overnight), while short-term (long-term) assets have a maturity of up to (above) one year. Top: relative standard deviation of liabilities to non-banks, i.e. deposits. Bottom: relative standard deviation of assets to non-banks, i.e. mostly loans. The first horizontal dashed line is in September 2008, the second in June 2009, and the third in December 2011.

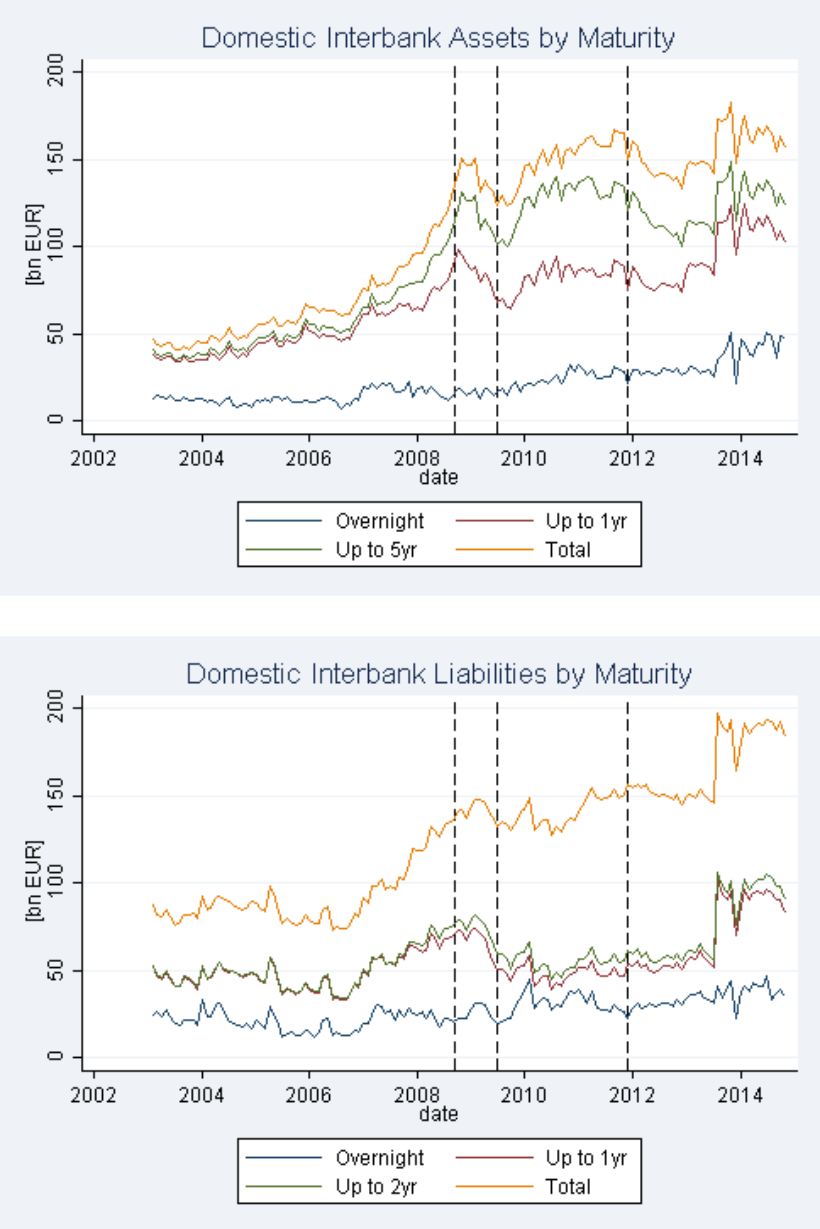

Figure 7: Domestic interbank assets (top) and liabilities (bottom) by maturity for the German commercial bank sector. The difference between interbank assets and liabilities is accounted for by interbank lending and borrowing to foreign banks. The first horizontal dashed line is in September 2008, the second in June 2009, and the third in December 2011. All values are in billion Euros.

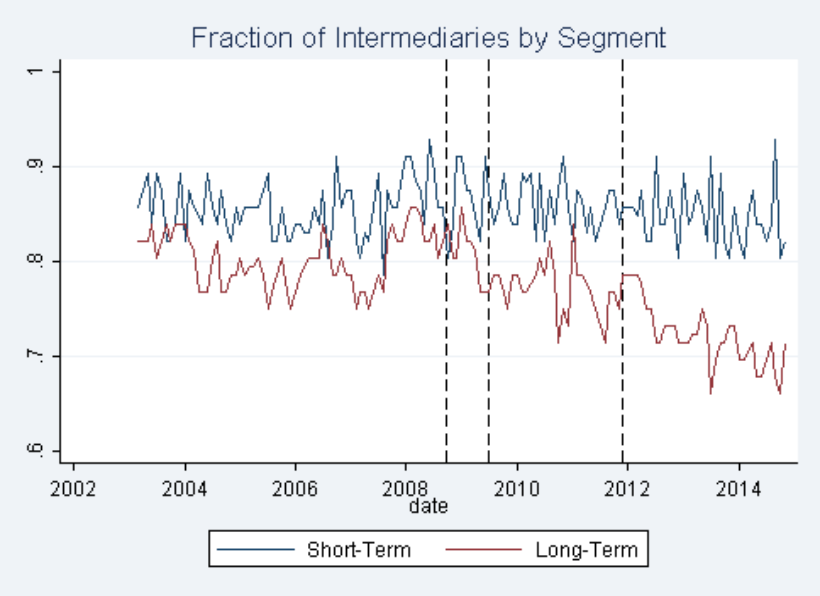

Figure 8: Fraction of commercial banks that are intermediaries in the interbank market. Interbank lending in the overnight segment is denoted as short-term. Interbank lending with a longer maturity than overnight is denoted as long-term. We define banks to be intermediaries in the short-term segment of the interbank market if they have a positive amount of interbank assets and interbank liabilities in the short-term (long-term) segment. The first horizontal dashed line is in September 2008, the second in June 2009, and the third in December 2011.

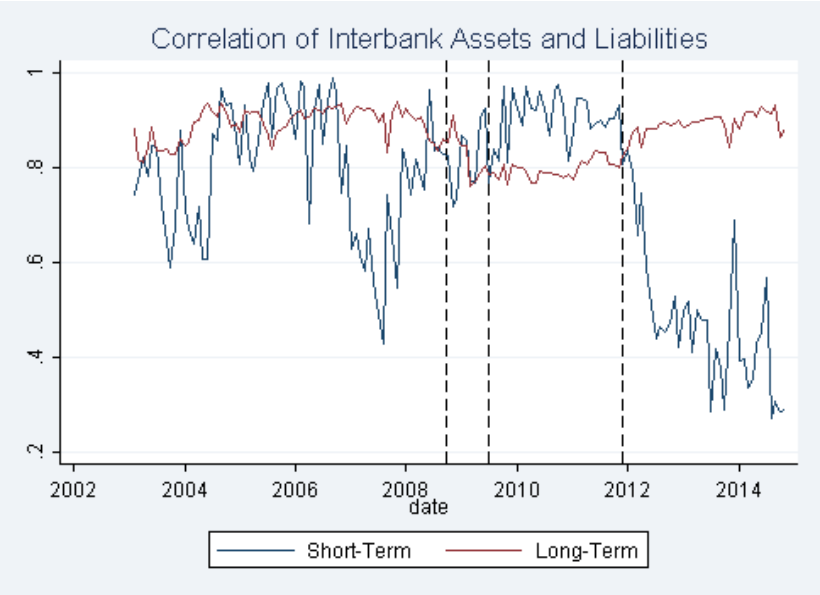

Figure 9: Pearson correlation of interbank assets and liabilities in the short- and long-term segment for commercial banks in Germany. Interbank lending and borrowing in the overnight segment is denoted as short-term. Interbank lending and borrowing with a longer maturity than overnight is denoted as long-term. The first horizontal dashed line is in September 2008, the second in June 2009, and the third in December 2011.

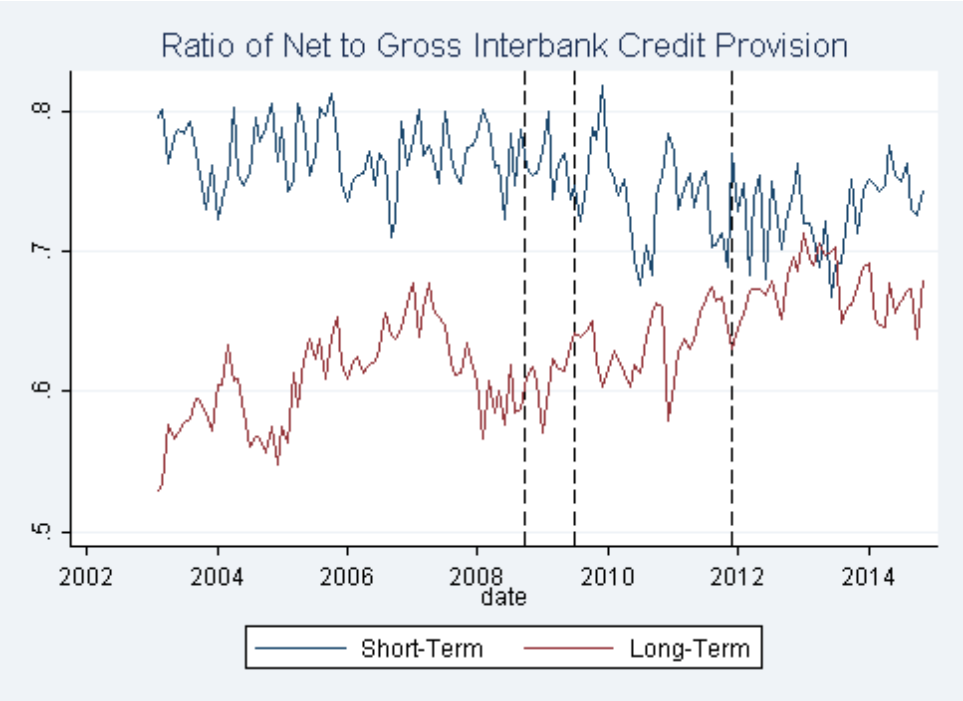

Figure 10: Ratio of net to gross interbank lending in the short- and long-term segment for commercial banks in Germany. Value shown is the bank-average of the net to gross ratio of interbank lending, defined as the difference of interbank assets and liabilities divided by the sum of interbank assets and liabilities for a given point in time. The first horizontal dashed line is in September 2008, the second in June 2009, and the third in December 2011.

Table 1: Change in Net Interbank Lending. The dependent variable is the normalized change in net interbank lending Δ Net Interbank Lending, defined as the change in the difference between interbank assets and liabilities from the previous to the current period, divided by the total asset size in the previous month. Δ Loans denotes the change in claims of banks on non-banks. Δ Deposits denotes the change in claims of non-banks on banks. Δ Central Bank Assets denotes the change in all assets a bank holds at Deutsche Bundesbank. Δ Central Bank Liabilities denotes the change in all claims the central bank has on a bank. We control for a change in secured liabilities. All independent and control variables are normalized by the size of the bank in the previous period. The Full Sample is from February 2002 to December 2014, Pre-Crisis is from February 2002 until September 2008, and Crisis is from October 2008 until December 2014.

	Full Sample			Normal Sample			Crisis Sample		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Δ Loans	−0.859***	−0.864***	−0.874***	−0.914***	−0.924***	−0.931***	−0.750***	−0.758***	−0.781***
	(0.0500)	(0.0500)	(0.0522)	(0.0253)	(0.0269)	(0.0310)	(0.0798)	(0.0804)	(0.0823)
Δ Deposits	0.831***	0.836***	0.847***	0.913***	0.906***	0.908***	0.724***	0.735***	0.756***
	(0.0463)	(0.0455)	(0.0460)	(0.0265)	(0.0272)	(0.0298)	(0.0732)	(0.0749)	(0.0776)
Δ Central Bank Assets	0.194***	0.187***	0.160**	0.204*	0.144	0.111	0.238**	0.225**	0.197**
	(0.0712)	(0.0712)	(0.0647)	(0.116)	(0.128)	(0.163)	(0.0958)	(0.0962)	(0.0883)
Δ Central Bank Liabilities	−0.213***	−0.199***	−0.152***	−0.167**	−0.141**	−0.115	−0.275***	−0.269***	−0.208***
	(0.0546)	(0.0520)	(0.0454)	(0.0696)	(0.0658)	(0.0701)	(0.0572)	(0.0551)	(0.0516)
Constant	0.00267	0.00284	0.00653*	0.00230	0.00248	0.00406	−0.00319	−0.00353	−0.00176
	(0.00315)	(0.00322)	(0.00352)	(0.00285)	(0.00312)	(0.00383)	(0.00240)	(0.00239)	(0.00225)
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Number of Lags Included	12	12	12	12	12	12	12	12	12
Bank Fixed-Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Month Fixed-Effects	No	Yes	No	No	Yes	No	No	Yes	No
Bank×Year Fixed-Effects	No	No	Yes	No	No	Yes	No	No	Yes
N	7810	7810	7810	3740	3740	3740	4070	4070	4070
R^2	0.761	0.753	0.766	0.837	0.829	0.835	0.683	0.673	0.696

Standard errors in parentheses

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table 2: Change in Net Short-Term Interbank Lending. The dependent variable is the normalized change in net short-term interbank lending, Δ Net Interbank Lending, defined as the change in the difference between interbank assets and liabilities with a maturity no longer than overnight from the previous to the current period, divided by the total asset size in the previous month. Δ Long-term interbank Lending is the change in the dependent variable in the long-term segment, i.e. with a maturity longer than overnight. Δ Short-term (Long-term) Loans denotes the change in claims of banks on non-banks with a maturity of up to one year (above one year). Δ Short-term (long-term) Deposits denotes the change in claims of non-banks on banks in the overnight segment (with a maturity longer than overnight). Δ Central Bank Assets denotes the change in all assets a bank holds at Deutsche Bundesbank. Δ Central Bank Liabilities denotes the change in all claims the central bank has on a bank. We control for a change in secured liabilities. All independent and control variables are normalized by the size of the bank in the previous period. The Full Sample is from February 2002 to December 2014, Pre-Crisis is from February 2002 until September 2008, and Crisis is from October 2008 until December 2014.

	Full Sample	Normal Sample	Crisis Sample
	(1)	(2)	(3)
Δ Long-term net Interbank Lending	−0.598***	−0.702***	−0.574***
	(0.0830)	(0.0591)	(0.104)
Δ Short-term Loans	−0.560***	−0.709***	−0.429***
	(0.111)	(0.0575)	(0.133)
Δ Long-term Loans	−0.485***	−0.696***	−0.194
	(0.149)	(0.0537)	(0.139)
Δ Short-term Deposits	0.621***	0.801***	0.364***
	(0.107)	(0.0689)	(0.117)
Δ Long-term Deposits	0.391***	0.657***	0.290***
	(0.0772)	(0.126)	(0.0753)
Δ Central Bank Assets	−0.244*	−0.703***	−0.154
	(0.128)	(0.195)	(0.100)
Δ Central Bank Liabilities	0.382***	0.497***	0.256**
	(0.0997)	(0.0899)	(0.114)
Constant	−0.00277	−0.00799	−0.000533
	(0.00405)	(0.00486)	(0.00270)
Controls	Yes	Yes	Yes
Number of Lags Included	12	12	12
Month Fixed-Effects	Yes	Yes	Yes
Bank×Year Fixed-Effects	Yes	Yes	Yes
N	7810	3740	4070
R^2 (overall)	0.651	0.757	0.602

Standard errors in parentheses

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table 3: Change in Net Long-Term Interbank Lending. The dependent variable is the normalized change in net long-term interbank lending, Δ Net Interbank Lending, defined as the change in the difference between interbank assets and liabilities with a maturity longer than overnight from the previous to the current period, divided by the total asset size in the previous month. Δ Short-term interbank Lending is the change in the dependent variable in the overnight interbank market. Δ Short-term (Long-term) Loans denotes the change in claims of banks on non-banks with a maturity of up to one year (above one year). Δ Short-term (long-term) Deposits denotes the change in claims of non-banks on banks in the overnight segment (with a maturity longer than overnight). Δ Central Bank Assets denotes the change in all assets a bank holds at Deutsche Bundesbank. Δ Central Bank Liabilities denotes the change in all claims the central bank has on a bank. We control for a change in secured liabilities. All independent and control variables are normalized by the size of the bank in the previous period. The Full Sample is from February 2002 to December 2014, Pre-Crisis is from February 2002 until September 2008, and Crisis is from October 2008 until December 2014.

	Full Sample	Normal Sample	Crisis Sample
	(1)	(2)	(3)
Δ Short-term net Interbank Lending	−0.253***	−0.225***	−0.318***
	(0.0411)	(0.0552)	(0.0471)
Δ Short-term Loans	−0.222***	−0.288***	−0.181***
	(0.0585)	(0.0685)	(0.0563)
Δ Long-term Loans	−0.536**	−0.840***	−0.0484
	(0.233)	(0.0725)	(0.0363)
Δ Short-term Deposits	0.416***	0.493***	0.224***
	(0.110)	(0.153)	(0.0372)
Δ Long-term Deposits	0.304***	0.485***	0.202***
	(0.0788)	(0.122)	(0.0612)
Δ Central Bank Assets	−0.102*	−0.470***	−0.0798
	(0.0569)	(0.137)	(0.0553)
Δ Central Bank Liabilities	0.280**	0.428***	0.170**
	(0.123)	(0.146)	(0.0765)
Constant	−0.00268	−0.00809	−0.00423
	(0.00367)	(0.00573)	(0.00264)
Controls	Yes	Yes	Yes
Number of Lags Included	12	12	12
Month Fixed-Effects	Yes	Yes	Yes
Bank×Year Fixed-Effects	Yes	Yes	Yes
N	7810	3740	4070
R^2 (overall)	0.439	0.583	0.382

Standard errors in parentheses

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table 4: Change in Long-Term Gross Interbank Assets. The dependent variable is the normalized change in gross long-term interbank assets, defined as the change in interbank assets with a maturity longer than overnight from the previous to the current period, divided by the total asset size in the previous month. Δ Short-term Interbank Assets is the change in the dependent variable in the short-term segment, i.e. with a maturity no longer than overnight. Δ Short-term (Long-term) Loans denotes the change in claims of banks on non-banks with a maturity of up to one year (above one year). Δ Short-term (long-term) Deposits denotes the change in claims of non-banks on banks in the overnight segment (with a maturity longer than overnight). Δ Central Bank Assets denotes the change in all assets a bank holds at Deutsche Bundesbank. Δ Central Bank Liabilities denotes the change in all claims the central bank has on a bank. We control for a change in secured liabilities. All independent and control variables are normalized by the size of the bank in the previous period. The Full Sample is from February 2002 to December 2014, Pre-Crisis is from February 2002 until September 2008, and Crisis is from October 2008 until December 2014. Results from Tables 4 and 5 are obtained via estimating Equations (4) and (5) in a seemingly unrelated regressions framework.

	Full Sample	Normal Sample	Crisis Sample
	(1)	(2)	(3)
Δ Short-term Interbank Assets	−0.393***	−0.4882***	−0.3496***
	(0.0650)	(0.07389)	(0.0710)
Δ Short-term Loans	−0.313***	−0.45311***	−0.2130***
	(0.0627)	(0.0707)	(0.06123)
Δ Long-term Loans	−0.0731	0.0325	0.0624
	(0.0472)	(0.03716)	(0.04839)
Δ Short-term Deposits	0.362***	0.5347***	0.1988***
	(0.0796)	(0.0899)	(0.0680)
Δ Long-term Deposits	0.2633***	0.3871***	0.1921***
	(0.057)	(0.0757)	(0.0635)
Δ Central Bank Assets	−0.1753**	−0.409***	−0.1174*
	(0.0803)	(0.0778)	(0.0604)
Constant	−0.0010	−0.00212	0
	(0.0027)	(0.00289)	(0.0341)
Controls	Yes	Yes	Yes
Number of Lags Included	12	12	12
Bank Fixed-Effects	Yes	Yes	Yes
Month Fixed-Effects	Yes	Yes	Yes
N	7810	3740	4144

Standard errors in parentheses

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table 5: Change in Long-Term Gross Interbank Liabilities. The dependent variable is the normalized change in gross long-term interbank liabilities, defined as the change in interbank liabilities with a maturity longer than overnight from the previous to the current period, divided by the total asset size in the previous month. Δ Short-term Interbank Liabilities is the change in the dependent variable in the short-term segment, i.e. with a maturity no longer than overnight. Δ Short-term (Long-term) Loans denotes the change in claims of banks on non-banks with a maturity of up to one year (above one year). Δ Short-term (long-term) Deposits denotes the change in claims of non-banks on banks in the overnight segment (with a maturity longer than overnight). Δ Central Bank Assets denotes the change in all assets a bank holds at Deutsche Bundesbank. Δ Central Bank Liabilities denotes the change in all claims the central bank has on a bank. We control for a change in secured liabilities. All independent and control variables are normalized by the size of the bank in the previous period. The Full Sample is from February 2002 to December 2014, Pre-Crisis is from February 2002 until September 2008, and Crisis is from October 2008 until December 2014. Results from Tables 4 and 5 are obtained via estimating Equations (4) and (5) in a seemingly unrelated regressions framework.

	Full Sample	Normal Sample	Crisis Sample
	(1)	(2)	(3)
Δ Short-term Interbank Liabilities	−0.0537	−0.1214***	−0.01482
	(0.0340)	(0.0412)	(0.0197)
Δ Short-term Loans	0.0326*	0.0447**	0.0151*
	(0.0188)	(0.0190)	(0.00778)
Δ Long-term Loans	0.5286**	0.8428***	0.0390*
	(0.2343)	(0.09378)	(0.02284)
Δ Short-term Deposits	−0.0253*	−0.00978	−0.0068
	(0.0151)	(0.00652)	(0.0061)
Δ Long-term Deposits	−0.0535*	−0.10102***	−0.0396*
	(0.0294)	(0.03557)	(0.0216)
Δ Central Bank Liabilities	−0.0547	−0.0349	−0.0514
	(0.0339)	(0.0233)	(0.0471)
Constant	0.0000	0.00025	−0.00247*
	(0.0018)	(0.00193)	(0.00127)
Controls	Yes	Yes	Yes
Number of Lags Included	12	12	12
Bank Fixed-Effects	Yes	Yes	Yes
Month Fixed-Effects	Yes	Yes	Yes
N	7810	3740	4144

Standard errors in parentheses

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

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