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Fundamentals matter: idiosyncratic shocks and interbank relations

Peter Bednarek
(Deutsche Bundesbank)

Valeriya Dinger
(University of Osnabrueck)

Natalja von Westernhagen
(Deutsche Bundesbank)

Deutsche Bundesbank, Wilhelm-Epstein-Straße 14, 60431 Frankfurt am Main,
Postfach 10 06 02, 60006 Frankfurt am Main

Tel +49 69 9566-0

Please address all orders in writing to: Deutsche Bundesbank,
Press and Public Relations Division, at the above address or via fax +49 69 9566-3077

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Non-technical Summary

Research Question

We examine whether the inability of some banks to roll over their interbank position during the 2007 financial crisis was due to a failure of the interbank market in reallocating liquidity efficiently within the banking sector, i.e. a frozen interbank market. During the crisis banks were hit by global aggregate as well as idiosyncratic, i.e. bank-specific shocks. The crucial questions are how stable is interbank lending to shocks of a different kind and how periods of market turmoil affect the general functioning of market discipline.

Contribution

A number of features clearly distinguish our paper from the existing literature. First, we control not only for the volume but also for the persistence of interbank lending. This allows us to explore both intensive and extensive margins of interbank market dynamics. Second, we are the first that by disentangling the effects and the inherently differing information content of aggregate and idiosyncratic shocks, provide evidence of whether the inability of some banks to roll over their interbank positions was due to a failure of the interbank market, or rather to revised bank-level risk perceptions that lead to a stressed money market. Third, the length of our sample allows us to make comparisons between normal and crisis times. In detail, we analyse the most extensive dataset so far, comprising over 1.9 million interbank lending relationships of more than 3,500 German banks conducted between 2000 and 2012.

Results

The inability of some banks to roll over their interbank position and the ensuing financial market turmoil was not due to a failure of the interbank market *per se* but rather to bank-specific shocks affecting the banks' capital, liquidity and credit quality and revised bank-level risk perceptions. Most importantly, our results uncover a so far undocumented ability on the part of the interbank market to distinguish between banks of different quality in times of aggregate distress. We show empirical evidence that questions the hypothesis of market discipline being undermined by a lower sensitivity to fundamentals in times of aggregate market turmoil. In fact, our results show that the negative effect of higher risk levels is even larger in the crisis period than in the non-crisis period. In this regard, relationship banking is not capable of containing these frictions, as hard information seems to dominate soft information.

NICHTTECHNISCHE ZUSAMMENFASSUNG

FRAGESTELLUNG

Wir untersuchen, in welchem Ausmaß die Finanzmarktkrise des Jahres 2007 zu einem Marktversagen auf dem Interbankenmarkt geführt hat, z.B. durch eine unzureichende Finanzierung fundamental gesunder Banken. Während der Finanzmarktkrise waren diese sowohl aggregierten als auch idiosynkratischen Schocks ausgesetzt, d.h. Schocks, die einerseits den Gesamtmarkt und andererseits die individuelle Bank betreffen. Die entscheidenden Fragen in diesem Zusammenhang sind, wie stabil Interbankenmärkte gegenüber Schocks unterschiedlichen Typs sind und wie sich Perioden allgemeiner Marktunsicherheit auf die Funktionsweise von Marktdisziplin auswirken.

BEITRAG

Unsere Analyse unterscheidet sich wesentlich von der bisherigen Literatur. Erstens zielt unsere Studie nicht nur auf das Interbankenvolumen ab, sondern auch auf die Beständigkeit von Interbankenbeziehungen über die Zeit. Diese Herangehensweise ermöglicht es, die gesamte Bandbreite der Interbankenmarktdynamik zu untersuchen. Zweitens sind wir die ersten, die systematisch zwischen aggregierten und idiosynkratischen Schocks unterscheiden und damit die Verwerfungen auf dem Interbankenmarkt erklären und quantifizieren. Drittens erlaubt uns die Länge unserer Beobachtungsperiode nicht nur den Krisenzeitraum selbst, sondern auch die Vorkrisenperiode zu untersuchen. Insgesamt besteht unser Datensatz aus über 1,9 Millionen Kreditbeziehungen von mehr als 3.500 Banken in den Jahren 2000 bis 2012.

ERGEBNISSE

Unseren Ergebnissen zufolge sind die Verwerfungen auf dem Interbankenmarkt nicht auf ein Marktversagen, sondern maßgeblich auf fundamentale Faktoren zurückzuführen; vor allem auf Schocks der bankindividuellen Kapital- und Liquiditätsbasis sowie auf eine Verschlechterung der Kreditqualität. Das zentrale Ergebnis ist, dass wir eine bis dato nicht dokumentierte Eigenschaft des Interbankmarktes aufzeigen, nämlich die Eigenschaft, zwischen Banken hoher und niedriger Qualität in Zeiten allgemeiner Marktunsicherheit zu unterscheiden. Somit entkräften wir empirisch die Hypothese einer geringen Relevanz fundamentaler, harter Informationen im Fall hoher Marktunsicherheit. Vielmehr deuten unsere Ergebnisse darauf hin, dass die Sensitivität der Marktteilnehmer gegenüber bankindividuellen Risiken zugenommen hat. Weiche Informationen, die durch wiederkehrende Kreditbeziehungen zwischen den Instituten in der Vergangenheit generiert wurden, sind dagegen weniger bedeutend.

BUNDESBANK DISCUSSION PAPER NO 44/2015

FUNDAMENTALS MATTER: IDIOSYNCRATIC SHOCKS AND INTERBANK RELATIONS*

Peter Bednarek
Deutsche Bundesbank

Valeriya Dinger
University of Osnabrueck

Natalja von Westernhagen
Deutsche Bundesbank

ABSTRACT

Our results uncover a so far undocumented ability of the interbank market to distinguish between banks of different quality in times of aggregate distress. We show empirical evidence that during the 2007 financial crisis the inability of some banks to roll over their interbank debt was not due to a failure of the interbank market *per se* but rather to bank-specific shocks affecting banks' capital, liquidity and credit quality as well as revised bank-level risk perceptions. Relationship banking is not capable of containing these frictions, as hard information seems to dominate soft information. In detail, we explore determinants of the formation and resilience of interbank lending relationships by analyzing an extensive dataset comprising over 1.9 million interbank relationships of more than 3,500 German banks between 2000 and 2012.

Keywords: financial stability, interbank market, aggregate and idiosyncratic shocks, relationship banking, risk perception, market discipline

JEL Classification: E50, G01, G10, G21

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1 INTRODUCTION

Observing the interbank market distress of 2007-2008, major central banks around the world tried to contain the macroeconomic consequences by means of broad interventions, including not only injecting additional liquidity into the banking sector but also an adjustment of monetary policy instruments (Gabrieli and Georg, 2014). The large scale of these policies over the past few years has effectively made central banks the main money market intermediaries (Bräuning and Fecht, 2012). Such interventions have been successful in preventing liquidity crunches, but come at the cost of neglecting the market discipline mechanism inherent to the interbank market. The question of how reliable the functioning of market discipline is in times of aggregate distress is therefore crucial for an evaluation of the benefits and costs of the interbank interventions. In this regard, empirical research has already documented the role played by the intensity of interbank relations for the availability and the conditions of interbank borrowing in times of crisis (Cocco et al., 2009, Affinito, 2012, Bräuning and Fecht, 2012). However, it is still an open question how interbank positions change in response to idiosyncratic shocks and whether this change is contingent in times of aggregate distress.

In this paper, we close this gap and empirically examine the sensitivity of bilateral interbank positions to both aggregate and idiosyncratic shocks. We employ several definitions of idiosyncratic shocks which are based on measuring the relative deterioration of a bank's capital, liquidity or credit quality. We then study how idiosyncratic shocks which hit the borrowing or lending bank affect the intensity of interbank positions in normal times and time of aggregate distress. By disentangling the role of idiosyncratic and aggregate shocks, we aim to provide evidence of whether the turmoil in the interbank market was due to a general failure of the interbank market in reallocating liquidity efficiently within the banking sector itself, or rather to revised bank-level risk perceptions that lead to a stressed money market.

The study is based on data on the bilateral exposures of German banks for the period 2000Q1 to 2012Q3. We employ a two-stage estimation model which first evaluates the probability of the existence of a bilateral interbank position and then estimates the determinants of the volume of this position.

Our results show that aggregate distress has a statistically significant negative effect on bilateral interbank exposures, although, in economic terms, idiosyncratic shocks are economically by far more important. Also, we find that interbank positions react to idiosyncratic shocks even if the market as a whole is in distress. More specifically, we show that lending banks statistically and economically reduce their exposures to banks that have suffered idiosyncratic shocks. In terms of existing relationships, we find that these are not fully terminated following a shock but that their intensity is reduced. Interestingly, the intensity of bilateral exposures is driven not only by the shocks that hit the borrowing bank but also by those that hit the lending bank.[1] In the case of borrowing banks, we find that the intensity of the interbank relation is sensitive to shocks to capital, liquidity and to credit quality. This sensitivity is highest, however, for the shocks to a borrower bank's liquidity position. In the case of lending banks, we find that shocks to their capitalization do not affect the intensity of interbank relations, but shocks to liquidity and, in particular, shocks to credit quality have a strong negative effect. Further, the effects are nonlinear for both borrowing and lending banks. They are also contingent on the aggregate state of the financial system.

Moreover, we explore whether relationship banking can outweigh the negative effects induced by bank-specific shocks. Unlike results of earlier studies, which find that relationship banking helps to overcome financial instability, we show distinct evidence that hard information seems to dominate soft information, as neither longer nor more intense

[1] This is contrary to Afonso et al. (2011) who find a relationship for the US interbank market between bank characteristics and the volume of the exposure only for the borrowing banks but not for the lending banks.

interbank relationships in the past contain the negative effects of either aggregate or idiosyncratic shocks regarding the banks' capital, credit quality or liquidity.

A number of features underline the novelty of our paper relative to the existing literature. First, we control not only for the volume but also for the existence of lending. This allows us to explore both intensive and extensive margins of interbank market dynamics. In this regard, we are the first to utilize a Heckman Correction methodology to counter the empirical problem of sample selection arising from the fact that banks participating in a bilateral interbank relation may differ in important unmeasured ways from banks which do not participate. For example differing business models may foster interbank market participation or restrain banks from doing so. Hence, we provide insights into both the main drivers which increase or decrease the probability of forming bank-to-bank relationships, as well as their impact on interbank lending exposures. Second, the length of our sample allows us to make comparisons between normal and crisis times. In detail, we analyze the most extensive dataset so far comprising over 1.9 million interbank lending relationships of more than 3,500 German banks conducted between 2000Q1 and 2012Q3.

Our results contribute to several strands of the literature. To start with, by showing that interbank exposure, even in times of aggregate distress, is related to the conditions of the borrowing bank, we confirm an insight gained from various studies on market discipline in banking. Thus, Goodfriend and King (1988), Kaufman (1991), Berger (1991) and Schwartz (1992), for example, also find that banks are well-informed parties in judging the solvency of illiquid peer banks. This view has been debated by Goodfriend (2002) and Martin and McAndrews (2007). These papers claim that banks are not apt to monitor other banks, because the implicit guarantee supplied by central banks, which are expected to intervene in case of crisis, undermine banks' incentives to monitor their peers. More recent studies, like DeYoung et al. (1998), Peek et al. (1999), Berger et al. (2000), and Furfine (2002) reconcile the two sides of the debate by finding that banks possess knowledge regarding other banks' health, even while highlighting that this is only complementary to the knowledge of central banks. More specifically, Furfine (2001) documents that interbank interest rates in the US federal funds market reflect in part the credit risk of the borrowing banks. Similarly, King (2008) demonstrates that high-risk banks pay more than safe banks for interbank loans. Dinger and von Hagen (2009) show that in systems characterized by longer-term interbank exposures the monitoring role of lenders is more important, and Bräuning and Fecht (2012) find evidence for the existence of private information in the German interbank market, as relationship lenders were already charging higher interest rates to their borrowers in the run-up to the financial crisis of 2007-2008, whereas, during the crisis, borrowers paid lower rates on average to their relationship lenders than to spot lenders.

While, in the case of a well-functioning interbank market, the evidence on peer monitoring is mixed, for times of aggregate market turmoil most existing literature predicts that market discipline will be further undermined by a lower sensitivity to fundamentals (Hasan et al., 2013, Levy-Yeyati et al., 2004, Martinez-Peria and Schmukler, 2001, Flannery, 1996, Freixas and Jorge, 2008, and Heider et al., 2009). These models have in common that information asymmetry becomes worse during a crisis when the percentage of risky banks goes up and investors are unable to differentiate among the credit risks of individual banks. As a result, lenders require a higher yield to participate in the market. In cases of particularly severe distress, adverse selection issues can generate a complete freeze of the interbank market. Following this argument, central banks should intervene as a lender of last resort in order to prevent liquidity distress of solvent banks. The results of our study contradict this view and uncover a so far undocumented ability on the part of the interbank market to distinguish between banks of different quality in times of aggregate distress.

The remainder of our paper is organized as follows. In Section 2 we describe the data. Section 3 introduces the methodology. The main estimation results are presented in Section 4. Section 5 describes a battery of robustness tests. Section 6 concludes.

2 DATA AND SUMMARY STATISTICS

We construct a unique unbalanced panel bank-to-bank level dataset that contains information about the German interbank market from the first quarter of 2000 to the third quarter of 2012.[2][3] The construction of the dataset makes use of several data sources. The central source is the Deutsche Bundesbank's credit register data (MiMik) which contains information on all big individual exposures of German banks to firms (including other banks). This source gives us information on whether a bank with a German charter has lent to any other banks and, if so, how much of the interbank lending is outstanding at the end of each quarter. Next, we add information from the balance sheet of the lending and borrowing banks. This information stems from the monthly balance sheet statistics Bista and BAKIS.[4] Moreover, we utilize the banks' estimates of their counterparty's *probability of default (PD)* which has been part of the general MiMik dataset since 2008.[5]

2.1 DATA OVERVIEW

Panel A of Table 1 provides summary statistics on the number of banks, their distinct bank group and the number of bank-quarter observations on those entities as well as the overall number of observations. In total, our dataset covers an extensive amount of 4.6 million bank-quarter observations on a total of 3,550 German banks. In around 40% of

[2] Details on the credit register can be found in Schmieder (2006), and in published work by Schertler et al. (2006), Hayden et al. (2007) and Ongena et al. (2012), for example. The Bundesbank also maintains a website with working papers based on its credit register.

[3] For a more detailed definition, see Section 14 of the Banking Act (*Deutsche Bundesbank*, 2001). If exposures existed during the reporting period but are partly or fully repaid, the remaining exposure is reported even if the amount is zero. Due data limitations we take the actual amount of exposures into consideration that is the reported end-quarter amounts.

[4] We match the end of the quarter value of the Bista variables to the quarterly frequency of the interbank data. A few balance sheet items - such as non-performing loans - are not covered by Bista. We therefore uncover them from BAKIS, which is an information system that is shared between the Bundesbank and BaFin (the German Federal Banking Supervisory Office) and comes with annual frequency.

[5] Each counterparty is assessed by several different creditor banks; we take the median value of all estimated PDs.

these bank-quarter observations we detect actual bank lending relationships between a creditor bank C and a borrower bank B. In the minority of the cases, lending is conducted between banks belonging to the same *bank holding company (BHC)*. Surprisingly, we detect a considerable amount of reciprocal lending relationships, that is more than 820,000 bank-quarter observations show a pattern of a contemporaneous reverse lending from the initial borrowing bank B to creditor bank C.

Moreover, the German interbank market is not fragmented along the lines of the traditional three-pillar structure of the German banking system, in which private commercial banks form the first pillar, public banks, such as *Landesbanken* and saving banks, form the second pillar, and cooperative banks the third pillar. We detect a considerable interconnection between all market participants, where the large banks such as the big, i.e. major banks, regional banks and the *Landesbanken* emerge mostly as borrowers, and savings and cooperative banks emerge as lenders (see Craig et al. 2015). For instance, savings banks provide lending not only to the *Landesbanken* but also to private mortgage banks and big banks.

2.2 (INTER)BANK CHARACTERISTICS

Panel B of Table 1 provides descriptive statistics on these interbank exposures as well as some initial impressions of how German interbank relationships are structured. Interbank exposures and, especially, reciprocal exposures exhibit a strong variance with mean values of €51 million and €86 million and a standard deviation (SD) of around €0.9 billion and €1.4 billion, respectively. Following Furfine (1999), we measure the strength of an interbank relation by (i) the duration of the bilateral exposure, as well as by (ii) the concentration of the banks' lending and/or borrowing activity. Regarding the relationship's duration, we calculate *Credit relation span* by adding up the bank quarters of a creditor bank C providing continuous lending to a specific borrower bank B. As in the case of interbank lending, both borrower and creditor are financial institutions and can, for instance, cooperate by mutually providing liquidity to each other. We also consider the possible two-sided nature of interbank relationships by computing *Reciproc relation span* by adding up the quarters the current borrower bank B is continuously lending to creditor bank C. Accordingly, *Total relation span* adds up the number of quarters in which both banks C and B are related to each other in either direction. In line with Petersen and Rajan (1994) *Total relation span* is a proxy for private information mitigating problems of asymmetric information. Overall, interbank relationships between distinct bank pairs last on average for around three years. If a relationship breaks at some point, it takes approximately the same amount of time for a relation to be re-established. Regarding the concentration on one lender/borrower, we follow Cocco et al. (2009) and Bräuning and Fecht (2012) and compute the amount lent by a creditor bank C to a borrower bank B relative to the overall amount lent by bank C in any distinct quarter t. Formally, this *lender preference index (LPI)* is defined as

$$LPI_{CB_t} = \frac{Exposure_{CBt}}{\sum_B Exposure_{CBt}} * 100 \tag{1}$$

whereas we set the variable to zero if the denominator is zero, i.e. if the lender did not lend at all. Similarly, we compute the *borrower preference index (BPI)* as the amount borrowed by bank B from bank C relative to the overall borrowing by bank B in quarter t

$$BPI_{CB_t} = \frac{Exposure_{CBt}}{\sum_C Exposure_{CBt}} * 100. \tag{2}$$

Again we detect a considerable high variance with some banks lending to and borrowing from only a single counterparty, whereas the mean values of the indices are 6.1% and 6.3%, respectively.

Last, Panel C provides descriptive statistics on the most important bank characteristics.[6] Regarding *size*, most banks in our sample are rather small ones with total assets amounting to €378 million, but with €3.6 billion as a mean value. In general,

[6] To control for spurious outliers we delete all observations except *Size* at the 0.1% level. As robustness checks we rerun our specifications with varying measures or without any outlier correction measures. Results do not change qualitatively or quantitatively .

regulatory capital ratios (CAPR) are quite high with a mean (median) value of 20.4% (13.8%). The importance of the traditional bank loan for financial intermediation in Germany is mirrored by the *loans to asset ratio (LAR)*, as loans to non-financials comprise around 60% of the banks' balance sheet. Around 4% of those loans are *non-performing (NPLR)*[7]. 20% of the banks' assets are *liquid (LIQR)* and the *return on risk-weighted assets (ROA(rw))* amounts in the mean (median) to 1.2% (1.7%). The mean (median) *Z-score* and *PD* values amount to 31.8 (29.5) and 0.85% (0.035%), respectively.

3 METHODOLOGY

3.1 BASELINE SPECIFICATION

This rich data source makes it possible to observe the behavior of nearly the entire German interbank market and the use of the bank-specific balance sheet information enables us to analyze the most important determinants of interbank market (in)stability. However, before we can make meaningful causal inferences some methodological shortcomings have to be solved.

First, between the first quarter of 2000 to the third quarter of 2012 a number of bank mergers took place. We carry out a merger correction procedure by creating a new separate bank after the merger takes place.[8] The relationships' duration still amounts to nearly three years, which should be a sufficient amount of time to overcome asymmetric information due to relationship banking (Rochet & Tirole, 1996). Nevertheless, results are robust to alternative specifications.

Second, and most important, we have to account for the possibility of an endogenous sample selection, as around 60% of our bank quarters do not contain an interbank lending relationship, because either banks stopped participating in the interbank market in general

[7] Especially saving and cooperative banks exhibit high values of non-performing loans.

[8] Our approach is based on separating the pre-merger banks from the merged bank. In the end, we have three banks, which are treated independently from each other. We repeat this procedure as often as a merger takes place. Each time a new merged bank receives a new identification number, we drop the target banks in that quarter.

or interrupted a specific interbank relationship. A sample selection bias may arise if the sample consists only of banks which choose to participate in the interbank market and these banks differ in important unmeasured ways from banks which do not participate. We utilize the Heckman Correction methodology to overcome this issue. That is, we first estimate the probability of an interbank lending relationship taking place with a Probit (selection) equation by MLE

$$Prob(credit\,relation_{CB} = 1|X) = \Phi(X\gamma) \tag{3}$$

with X being a vector of explanatory variables, γ a vector of unknown parameters and Φ the cumulative distribution function of the standard normal distribution.[9] Afterwards, we compute the inverse Mills ratio

$$\hat{\lambda}(k) = \frac{\phi(k)}{\Phi(k)} \tag{4}$$

as the ratio between the standard normal probability density function ϕ and the standard normal cumulative distribution function Φ, each evaluated at observation k, and utilize $\hat{\lambda}$ finally in the second step as a further regressor in a standard OLS regression model.[10]

The dependent variable for the second step is the logarithmic change in the exposure of creditor bank C to borrower bank B and is defined as

$$Exposure\ change_{CB_t} = ln(Exposure_{CB})_t - ln(Exposure_{CB})_{t-1}. \tag{5}$$

Moreover, to compare our results with those of earlier studies we also employ LPI and BPI concentration measures as proxies for the change in the intensity of an interbank relation. Accordingly, we estimate the following baseline regression model with parameters estimated using OLS

9 We use clustered standard errors with the lending relationship between creditor bank C and borrower bank B as our cluster variable.

10 We use robust standard errors.

$$\begin{bmatrix} Exposure\ change_{CB_t} \\ LPI_{CB_t} \\ BPI_{CB_t} \end{bmatrix} = \beta X + \beta_\lambda \hat{\lambda}(k) + v_{CB_t}$$

$$= \beta_0 + \beta_1 Crisis + \beta_2 Relation_{CB_t} + \beta_3 \sum_{i=C,B} Controls_{i_{t-1}} + \beta_\lambda \hat{\lambda}(k) + u_{CB_t} \quad (6)$$

where X is the vector of explanatory right-hand side (RHS) variables, β a vector of unknown parameters, β_λ the unknown parameter of the estimated inverse Mills ratio $\hat{\lambda}$ and u_{CB_t} is the composite error term including the time invariant unobserved effect. In detail, $Crisis$ is a varying time dummy variable capturing the effects of the 2007 financial crisis period and $Relation_{CB_t}$ is a vector of relationship variables defined as

$$Relation_{CB_t} = [Total\ relation\ span_{CB_t} \quad ln(Exposure)_{CB_{t-1}} \quad ln(Reciproc\ exposure)_{BC_t} \quad BHC\ dummy_{CB_t}] \quad (7)$$

which is a proxy for private information. As described in the previous section $Total\ relation\ span_{CB_t}$ captures the interbank history of a specific pair of banks C and B by adding up the quarters in which those two banks have either a lending or borrowing relationship in t. To proxy the bank's relationship intensity we use the logarithm of the lagged exposure from the creditor bank C to the borrower bank B, $\ln(Exposure)_{CB_{t-1}}$. Moreover, to analyze the effect of reciprocity we also utilize the reciprocal lending from the initial borrower bank B to the creditor bank C, $\ln\left(Reciproc\ exposure\right)_{BC_t}$. In the case of this variable we take the contemporaneous values, since we are particularly interested in exploring whether truly reciprocal exposure increases the stability of the relation[11]. And finally, we account with a dummy variable for banks belonging to the same *bank holding company (BHC)* where the variable $BHC\ dummy_{CB_t}$ takes the value of one if both banks belong in quarter t to the same BHC and zero otherwise. Regarding the set of control variables, we use standard bank characteristics with a one quarter lag and a set of dummy

[11] Results do not change qualitatively or quantitatively if we utilize reciprocal exposure with one quarter lag.

variables classifying each bank in any distinct quarter into a specific bank group listed in Panel A of Table 1. We utilize both types of controls for every bank i. More precisely, bank-specific characteristics are the bank's logarithm of total assets $\left(Size_{i_{t-1}}\right)$, the loans to assets ratio ($LAR_{i_{t-1}}$), the liquidity to assets ratio ($LIQR_{i_{t-1}}$), the regulatory capital ratio ($CAPR_{i_{t-1}}$) and the return on risk-weighted assets ratio ($ROA(rw)_{i_{t-1}}$).[12]

Table 2 describes all variables employed in the estimations. Its Panel A illustrates the left-hand side (LHS) variables, while Panel B is focused on the right-hand side (RHS) variables, including our fix set of control variables.

3.2 EXTENSIONS

To give an answer to the question of whether the German interbank market was frozen due to an aggregate shock disabling an efficient liquidity allocation or whether it was partially stressed due to bank-specific shocks and possibly revised risk perceptions, we expand this Heckit baseline model consisting of both model (3) and (6) stepwise. First, to analyze whether a longer or stronger interbank relationship in the past mitigates possible negative $Crisis$ effects, we expand the plain baseline models by interaction terms of the following form

$$Crisis * [Total\,relation\,span_{CB_t} \quad ln(Exposure)_{CB_{t-1}} \quad ln(Reciproc\,exposure)_{BC_t}]. \qquad (8)$$

Second, we augment the baseline models by $Risk_{i_{t-1(4)}}$ which is a vector of different lagged risk measures for every bank i defined as

$$\sum_{i=C,B} Risk_{i_{t-1(4)}} = \begin{bmatrix} NPLR_{i_{t-4}} \\ Z-score_{i_{t-1}}. \\ PD_{i_{t-1}} \end{bmatrix} \qquad (9)$$

and to analyze whether risk perception changes to some extent during periods of aggregate distress, we estimate an interaction term model also with an interaction term of the following form

[12] As robustness checks we utilize varying sets of control variables and use varying lags for our main variables of interest. Furthermore we rerun the models for private banks only, i.e without *Landesbanken*, savings and cooperative and cooperative central banks. Results do not change qualitatively or quantitatively.

$$Crisis * \sum_{i=C,B} Risk_{i_{t-1(4)}}. \qquad (10)$$

Third, and most important, we expand the baseline models (3) and (6) by an alternating set of idiosyncratic shock variables. In detail, we compute idiosyncratic shocks at the bases of the creditor, respectively the borrower bank's capitalization ($CAPR$), credit quality ($NPLR$), liquidity ($LIQR$) and profitability ($ROA(rw)$). Further, we specify shocks regarding the bank's $Z-score$ and PD. Our framework distinctively expands those of existing studies. For instance, Afonso et al. (2011) concentrate on the banks' non-performing loans and profitability, whereas Cocco et al. (2009) and Bräuning and Fecht (2012) do not explicitly account for these and measure liquidity risks solely via reserve holdings and the banks' maturity mismatch. Moreover, to the best of our knowledge we are the first to account for a possible non-linear behavior of these determinants by employing the following method to determine bank-specific shocks.[13] First, we construct the yearly distribution of each of the above variables and divide this distribution into its ten deciles. In a second step, we define an idiosyncratic shock as an alternating dummy variable that takes the value one if the value of the respective variable for the bank has moved by 1 (2,..., 9) decile(s) in an unfavorable direction from one quarter to another and zero otherwise. All in all, the basic idea is to stress-test somewhat not the bank's balance sheets to an unfavorable macroeconomic scenario, but rather the interbank relations to detect breaking points that, in turn, destabilize the interbank market itself. Hence, we expand both steps of the baseline Heckman Correction models by the following term

$$\sum_{i=C,B} \prod_{j=CAPR}^{PD} \prod_{x=1}^{9} Idiosyncratic\ shock_{ijx} \qquad (11)$$

which determines creditor and borrower bank i specific shock variables for every underlying shock variable j of any strength x. It can be seen that we run a comprehensive set of regressions analyzes in which the idiosyncratic shock variable changes in two

[13] Results of unreported tests where we examine the effect of quadratic terms indicate a non-linear behavior of those underlying bank determinants.

dimensions. First, with regard to the potential shock, we want to analyze shocks of the bank's capitalization, credit quality, liquidity, profitability and risk. And, second, the idiosyncratic shock variable alters regarding the strength of the shock, i.e. whether it is a moderate or a more serious shock, such as a heavy slip from one quarter to another amounting to several deciles in the underlying variable's distribution.

Lastly, to analyze possible differences between the crisis and the non-crisis period we estimate an interaction term model with an interaction term of the following form

$$Crisis * \sum_{i=C,B} \prod_{j=CAPR}^{PD} \prod_{x=1}^{9} Idiosyncratic\ shock_{ijx} \tag{12}$$

and to answer the question of whether relationship banking, i.e. a longer and more intense interbank relationship in the past, can help to overcome possible negative effects of idiosyncratic shocks, we expand the baseline models (3) and (6), finally, by

$$Relation_{CB_t} * \sum_{i=C,B} \prod_{j=CAPR}^{PD} \prod_{x=1}^{9} Idiosyncratic\ shock_{ijx}. \tag{13}$$

4 EMPIRICAL RESULTS

4.1 RELATIONSHIP BANKING AND THE 2007 FINANCIAL CRISIS

We start by presenting the results of the baseline regression model of the determinants of interbank lending and the effects of the 2007 financial crisis period in Table 3. To capture the effect of an aggregate shock we utilize a $Crisis$ variable which is a time dummy variable taking the value of one from 2007Q3 onwards (Column 1, 3, 5 and 7). In this quarter, several important events happened likely to disrupt market confidence, triggering general market turmoil, such as the announcement by the German bank *IKB* that it was in distress on July 30th and the close-down of two *BNP Paribas* funds on August

9th.[14] Additionally, we run robustness tests with altering crisis period definitions, for example also splitting the crisis period into different sub-crisis periods, such as the Commercial Paper crisis (2007Q3 - 2008Q3), the Lehman crisis (2008Q4 - 2009Q4) and the Euro crisis (2010Q1 - 2012Q3). Results of the latter, disaggregated $Crisis$ definition are presented in Column 2, 4, 6 and 8. Nevertheless, as results applying these alternating definitions do not vary a lot either economically or statistically, we adhere to the aggregated $Crisis$ definition in subsequent analyses.

With regard to the parameter estimates, columns 1 and 2 depict the results of the first step of the Heckman Correction method where the dependent variable is *Credit relation*, which is a binary variable taking the value one if there is a specific lending relationship between a creditor bank C and a borrower bank B, and zero otherwise. The results of the second step of the Heckman correction method are presented in columns 3 to 8, where the dependent variable in columns 3 and 4 is the *Exposure change* in log differences, the *lender preference index (LPI)* in columns 5 and 6, and the *borrower preference index (BPI)* in columns 7 and 8, respectively.

Not surprisingly, we detect a highly significant negative effect of $Crisis$ on the probability of establishing an interbank lending relationship, although the effect is most severe in the commercial paper and euro crisis period. The negative coefficients can be interpreted to some extent as rising search costs due to the inability to assess institutions' risk during the crisis. However, the actual economical effect is rather small. Unreported marginal effects show a decrease of between 1.5% and 9.6% in the probability.[15]

In contrast, $Crisis$ distinctively affects the lender and borrower preference indexes leading to a higher concentration of interbank lending and borrowing. It is unclear whether this is due to creditor banks tending to lend to a smaller number of banks and perhaps staying with those with which they have a stronger interbank relationship. As we do not

[14] As BNP Paribas became the first major financial group to acknowledge the impact of the sub-prime crisis by closing those two funds exposed to it, this date is generally seen as the start of the global credit crisis.

[15] To draw conclusions about the economic effects, we estimate both the probit model's marginal effects at mean (MEM) and its average marginal effects (AME) (Williams, 2011).

observe the price for liquidity, it could also be the case that borrower banks shift their borrowing to banks that provide them with cheaper liquidity. Indeed, Bräuning and Fecht (2012) show some evidence that, at the height of the 2007 financial crisis, relationship lenders charged lower interest rates than spot lenders.

Regarding the actual interbank exposures, we do see a negative effect of $Crisis$ but not a decisively strong one. Though the $Euro\ crisis$ coefficient is a substantially higher one should keep in mind that on December 21st 2011 and on February 29th 2012 the ECB instituted the long-term refinancing operation (LTRO) programs in which banks could lend in total over a trillion euros for a period of up to three years. Following Gabrieli and Georg (2014) who point out that the striking increase in risk premia in the Eurozone money market in 2008Q3 was clearly subsequent to rather than before the change in the operational framework involving a switch from a regular variable-rate tender procedure to a fixed-rate full allotment policy, it is more likely that those exceptional measures are the cause rather than the outcome of the reduced interbank lending activity.[16] Nevertheless, aggregated interbank lending is remarkably stable over time (Gabrieli and Georg, 2014). Figure 1 shows the amount of quarterly interbank lending as highly aggregated, while the solid line depicts interbank exposures without quarterly bank-to-bank exposures of €100 billion, and more and the dashed line shows aggregate interbank lending without exposures between banks belonging to the same BHC.[17] The beginning of the aggregated crisis period is indicated by the vertical bar at 2007Q3.

Although we do not adjust for price changes, it can be seen, however, that interbank exposures are surprisingly stable over time and actually rise to some extent even in distinct time frames of the crisis-period. Nevertheless, there is indeed a decrease in

[16] Unreported robustness tests show that in the full allotment period (2008Q4) itself the likelihood of interbank participation significantly drops between 1.6 and 7 percent but we do not detect reduced interbank market exposures in that nor in the preceding quarters. Hence, from an aggregated point of view in the case of Germany one could question the need to change the operational framework. Especially as the Italian Interbank market was not affected by the 2007 financial crisis either (Affinito, 2012).

[17] It is noteworthy that there is an upwards shift of excessive high bank-to-bank exposures of more than €100 billion since 2007Q3. All of these cases are conducted between parent banks and their affiliated mortgage banks. But as there is in some quarters of the crisis period only one such observation, we refrain from showing these data points. In general, excessive bank-to-bank exposures of more than €100 billion peak in 2008Q4 with an amount of €290 billion.

interbank exposures after 2008Q3 and 2010Q4, i.e. following the non-standard measures taken by the ECB.

4.1.1 Determinants of Relationship Banking

Besides the effects of the 2007 financial crisis period, we are particularly interested in the determinants that potentially foster bank-to-bank relationships. In this regard, all relationship proxies have a positive impact on the probability of renewing the lending relationship as well as on the concentration measures, except $Reciproc\ exposure$. In particular, belonging to same BHC strongly enhances the probability of a credit relationship and also the amount lent. Unreported marginal effects show an increase of up to 25% in the probability. Longer and stronger interbank relations in the past, on the other side, only impact positively on the probability of continuing lending, but do not lead to higher exposures. In fact, the opposite is true, implying that banks tend to hesitate to terminate relationships once they are established and instead prolong lending but on a reduced level, possibly avoiding risk concentration. In contrast, reciprocal lending shows the exact opposite results. Though it is negatively related to the probability of forming a lending relationship between a specific pair of a creditor bank C and a borrower bank B, reciprocal lending from the initial borrower B to creditor C leads to significantly higher exposures from C to B in the first place. The first result regarding the lower probability of forming a credit relationship due to reverse lending is not exactly odd, as it is possible to argue that borrower banks generally hesitate to lend during the same quarter in which they actually borrow. The second result however could be a initial indication that reverse relationship banking has a positive effect owing to the fact that it signals the bank's own soundness. Another possible explanation might be a swap in maturities. Unfortunately information on maturities is not directly available in our data.

4.1.2 BANK-SPECIFIC CHARACTERISTICS

Creditor and borrower bank specific variables reveal unexpected results insofar as higher capital ($CAPR$) and liquidity ($LIQR$) do not to lead to higher interbank exposures. In general, better capitalized banks seem to avoid participating in the interbank market, maybe because they tend to engage in more profitable retail business rather than interbank lending activities and also have different ways of financing. Indeed, creditor banks with higher loans to assets ratios (LAR) are less likely to participate in the interbank market and provide less lending as well, while consequently borrowing more. Results regarding the creditor and borrower bank's liquidity are to some extent more puzzling, but, though they are statistically significant, they are economically negligible. In contrast, parameter estimates of $Size$ indicate that larger banks are more likely to establish interbank lending relationships and that they receive and provide more interbank financing. As the borrower bank's coefficient is around seven times larger than the coefficient of the lender, it seems to be the case that this is not only due to the simple fact that larger banks are faced, on the one hand, with higher financing needs and, on the other hand, are also capable of providing more lending. For one thing, these results might reflect different business models. Descriptive statistics (Table 1 Panel A) already indicate that typically small banks, such as savings and cooperative banks, which can be characterized as retail deposit gathering institutions step in as interbank creditors, while larger banks such as big, regional and Landesbanken are mostly liquidity recipients. Nonetheless, it could also be the case that larger banks benefit from "too-big-to-fail" as there is a substantially higher likelihood of these banks being bailed out. In quantitative terms, a borrower bank's one SD increase in $Size$ enhances its interbank market borrowing capacity by around 70 percentage points. Not surprisingly, higher profitability ($ROA(rw)$) also enhances the probability as well as the amount a bank can borrow via the interbank market. Results regarding the concentration measures are in line with common expectations, for instance larger banks lending to or borrowing from a larger number of counterparties.

Finally, the highly significant and positive coefficient of the inverse mills ratio $lambda$ signifies that simple OLS would indeed produce upwardly biased estimates.

4.2 Interbank Relations and Risk in Times of Aggregate Market Turmoil

Results of the previous section reveal a remarkably stable interbank market, which was, in fact, affected to a high degree statistically but, on an aggregated level, not economically by the ongoing 2007 financial crisis. Considering the non-standard measures of the ECB which provided nearly inexhaustible cheap liquidity and which even changed its monetary policy instruments owing to some banks' inability to roll over their interbank position, it could be asked how the above results fit into this reality. To shed some light on this question, we expand our baseline Heckit models which consists of the probit model (3) in the first and the corresponding OLS model (6) in the second step by interaction terms (8) and (10), that is we interact the aggregated $Crisis$ variable with our relationship proxies and risk measures. Regarding the latter, we do only report the results for the non-performing loans to total loans ratio ($NPLR$). As a robustness check, we utilize the bank's $Z-score$ and for a sub-period since 2008Q1 the bank's PD as well, but qualitatively results do not change.[18]

Panel A of Table 4 shows the parameter estimates of these models, while the interaction term models' corresponding marginal effects at representative values ($Crsis = 1|0$) are shown in panel B. In both panels, columns 1 and 2 present results of the extended probit model where the dependent dummy variable is *Credit relationship*, and columns 3 and 4 present results of the corresponding extended OLS model with *Exposure change* in log differences as the dependent variable.

[18] Though PD parameter estimates show negative signs, only creditor banks exhibit a statistically significant reduction of interbank exposures. One possible explanation for these weak results might be given by Behn et al. (2014), who show that the introduction of Basel II-type, model-based capital regulation affected the validity of banks' internal risk estimates. They find that for the same firm (in our case bank) in the same year, both reported PDs and risk-weights are significantly lower, while estimation errors and loan losses are significantly higher for loans under the new regulatory approach. Thus, risk estimates for loans under the model-based approach systematically underestimate actual default rates. Also, results of the quadratic term model show a considerable decreasing effect of higher PDs for both creditor and borrower banks.

Regarding the effects of relationship banking on interbank exposures in times of aggregate uncertainty, columns 1 and 3 of Panel B present the marginal effects of the relationship variables for the interaction term model of Panel A, that is the marginal effects of a longer, more intense and reciprocal interbank relationship in the aggregated crisis and the non-crisis period. Generally, the effects of relationship banking on interbank exposures are qualitatively the same as those in the baseline model. Though banks hesitate to terminate bank-to-bank relationships once they have been established, it does not determine persistent interbank lending, as unlike to Affinito (2012), we do not detect a significantly positive effect of relationship banking in the crisis period. Although longer and more intense relations in the past do slightly increase the probability of renewing interbank lending relations in both the crisis and the non-crisis period, we do not detect any positive effects regarding the amount lent. Only reciprocal lending again increases interbank exposures from the initial creditor bank. Moreover, the positive effect is in fact two times larger in the crisis than during the non-crisis period. Whether this is actually due the fact that the initial borrower bank signals its own soundness, since reverse lending is even more important in crisis periods than in non-crisis periods or whether this is due to maturity swaps in this period is a matter for future research.

The most striking result, however, is that – in contrast to Martinez-Peria and Schmukler (2001) and others who claim that, in periods of aggregate distress, information about fundamentals is diluted – we show that the exact opposite is true with regard to the 2007 financial crisis. Columns 2 and 4 of Panel B present the marginal effects of the interaction term risk model of Panel A. Results reveal that the risk coefficient for borrower banks is more than five times larger in the crisis than during the non-crisis period. In other words, a one SD increase in risk reduces interbank exposures by around 18.7 percentage points during the crisis compared with a rather moderate decrease of 3.4 percentage points in the non-crisis period. Additionally, more risky creditor banks reduce their exposures less in the crisis than in the non-crisis periods and, in fact, are, overall, more likely to engage in the interbank market in times of aggregate distress.[19] Unreported results regarding the concentration measures show that riskier borrower banks lend from more counterparties as the BPI coefficient is statistical highly significant negative.

All in all, results uncover a so far undocumented ability of the interbank market to distinguish between banks of different quality in times of aggregate distress. As only the worst-performing banks have been rationalized by the interbank market, regulators should be reluctant to step in as a lender of last resort to avoid failures in liquidity reallocation fostering moral hazard.[20] Moreover, relationship banking does not stabilize interbank lending during periods of aggregate turmoil, as hard information seems to dominate soft information.

4.3 IDIOSYNCRATIC SHOCKS AND THE 2007 FINANCIAL CRISIS

One major result of the previous section is that we find that, even during times of aggregate market turmoil and high uncertainty, the intensity of interbank relations reacts to the risk characteristics of the participating banks. This result suggests that idiosyncratic factors might be important drivers of interbank market outcomes. Hence, in this section we expand the analysis by exploring the role of a wide range of idiosyncratic bank shocks that capture banks' most important determinants. As described in Section 3.2, we run a set of regression analyses where the idiosyncratic shock variable changes in two dimensions. First, with regard to the potential shock we want to analyze that is a shock of the bank's capitalization, credit quality, liquidity, profitability and risk. And, second, the idiosyncratic shock variable alters regarding the strength of the shock that is whether it is a moderate or a more serious one, i.e. a heavy slip from one quarter to another of several deciles in the

[19] In unreported tests we also examine the effect of quadratic terms of our risk measure and find a more concave risk-exposure relationship for borrower and a convex one for creditor banks, which confirms an increasing effect of risk for borrower banks and a diminishing effect for creditor banks.

[20] Indeed, unreported results show that in the full allotment period (2008Q4), that is the period where the ECB switched its operational framework from a regular variable-rate tender procedure to a fixed-rate full allotment policy, the markets' sensitivity to risk was rather impaired, as risk has a significantly negative impact on interbank borrowing outside the full allotment period and an insignificant one at that time. Nevertheless, this effect was not permanent, as banks generally exhibit a stronger sensitivity to risk in the crisis period than in the non-crisis period.

underlying variable's distribution.[21] All in all, the basic idea is to somewhat stress-test not the bank's balance sheets to an unfavorable macroeconomic scenario, but the interbank relations in order to detect breaking points which, in turn, destabilize the interbank market and to account for their non-linear behavior.

4.3.1 Idiosyncratic Shocks and Interbank Market Stability

The outcome of this extensive procedure is illustrated in Figure 2, where every tile depicts both the sign and the significance of the regression model's bank-specific shock variables.[22] In detail, it depicts the parameter estimates of bank-specific shocks regarding the creditor, respectively borrower bank's capitalization, credit quality and liquidity, with the dashed grey tiles representing significantly negative coefficients and the dotted white tiles denoting significantly positive coefficients. We present results only for these idiosyncratic shocks as they are the most important ones, severely affecting interbank relations and lending.[23] Generally, the left- hand side of Figure 2 shows the results of the first step of the Heckman selection method and the right-hand side shows the results of the second step. Moreover, parameter estimates of the idiosyncratic shock variables of the baseline models (3) and (6) expanded by the creditor and borrower bank-specific shock variables (11) are presented in the first and third lines and marginal effects at representative values ($Crisis = 1|0$) of the idiosyncratic shock variables of the baseline models (3) and (6) expanded by the interaction term (12) are shown in the second and fourth line marked by "*in crisis*".

Starting with idiosyncratic shocks regarding the banks' capitalization, it can be seen that, similar to results of the bank characteristics in the baseline model presented in Section 4.1, lower capital ratios do not affect creditors' interbank exposure. In fact, even the most severe creditor specific capital shocks do not affect the probability of continuing

[21] It is important to point out that the distribution of each of the underlying idiosyncratic shock variables is computed at a yearly base, as definitions of what constitutes an adequate or unfavourable level regarding those variables may change over time.

[22] Underlying regression results of all idiosyncratic shocks tested are reported in the Appendix (available on request).

[23] Similar to results of our baseline model in Section 4.1, lower profitability does not affect interbank stability at all. Even after very heavy declines in profitability from one quarter to another, creditor banks do not reduce interbank lending nor do borrower banks face problems prolonging their interbank positions. Higher risk in terms of shocks regarding the banks' Z-score or PD did not impair interbank relationships in the recent crisis either.

lending nor the amount lent.[24] Idiosyncratic borrower capital shocks do show a different behavior, however, revealing two important insights. First, borrower-specific capital shocks affect both the probability of continuing an interbank lending relation and the actual exposure itself. Second, results show like in Section 4.2, some kind of revised risk perception as the capital shocks' negative effect is triggered earlier in the crisis period. Nevertheless, while even moderate capital deteriorations in the distribution from one quarter to another have a significantly negative impact on the probability of continuing an interbank relation, we do not detect an actual reduction in interbank exposures before a borrower banks' capital ratio slips in the crisis period four deciles in its yearly distribution or, in other words, after an idiosyncratic shock of the strength *four*. In quantitative terms, borrower banks suffer from capital write-offs not before generally losing 38% of their regulatory capital, or 43% in the crisis period.[25] The actual economic effects of such a severe idiosyncratic capital shock are presented in Table 5, where Panel A shows the parameter estimation results of the baseline Heckit models (3) and (6) expanded by the interaction term (12), and Panel B depicts the corresponding marginal effects at representative values ($Crisis = 1|0$). In this regard, columns 1 and 2 present results of the interaction term model where the idiosyncratic shock variable is defined as a negative one decile change in the bank's capital ratio's distribution from one quarter to another. In columns 3 and 4 the shock is defined as a two decile change, and in the model presented in columns 5 and 6 the shock dummy variable takes the value one if the capital ratio slips four deciles or more, and zero otherwise. Results show a looming negative effect of borrower-specific capital shocks, starting with a slight decrease in the probability of continuing lending relationship in the case of a moderate shock of the strength *two*. The outcome of the actual breaking point is presented in Column 6 of Panel B, where we detect a reduction in lending of around 66 percentage points after a capital shock of the strength

[24] We detect negative effects only for creditor banks that are in the worst decile of the yearly capital distribution.

[25] The mean regulatory capital reduction for a borrower bank in the case of an idiosyncratic shock of the size five is 7.79 percentage points, which refers to a capital reduction in relative terms of 38.18% regarding a mean capital ratio of 20.4%. In contrast, the mean capital ratio of a borrower bank in the crisis period is 23.77% and the capital reduction in the case of an idiosyncratic shock of the size four is 10.12 percentage points, which amounts to a relative capital reduction of 42.57%.

four. Summing up, interbank relations are remarkably resistant with regard to bank-specific capital shocks, that is only severe capital-write offs of around 40% actually impair lending relationships. Most notable is the fact that idiosyncratic capital shocks affect interbank stability solely via the borrower side and even more in periods of aggregate turmoil. In contrast, creditor banks do not reduce their interbank market activity independently of their level of capitalization.

Idiosyncratic liquidity shocks show results which are quite similar to those of shocks regarding the banks' capitalization. Again, creditor banks seem to be remarkably resistant to liquidity drains, but, in contrast even small bank-specific liquidity shocks affect borrower banks negatively, i.e. reducing interbank lending. Table 6 presents regression results of interaction term models with the idiosyncratic shock variable alternating from a one decile change in columns 1 and 2, over a two decile change in columns 3 and 4, up to a bank-specific shock of the strength *three* in columns 5 and 6, i.e. a three decile change in the yearly distribution of the creditor, and the borrower liquidity ratio from one quarter to another, respectively. In general, we detect a higher reduction in interbank exposures, the stronger the idiosyncratic shock is. But most interestingly, effects are nearly four times larger in the non-crisis period than in the actual crisis period. For instance, an idiosyncratic shock in the crisis period of the strength *three*, i.e. a loss of around 34% in the borrower banks' liquid assets reduces interbank exposures by 11 percentage points. In contrast, a bank-specific shock of the same strength in the non-crisis period leads to reduction in interbank exposures of nearly 44 percentage points. One possible explanation for liquidity shocks affecting interbank lending less in the non-crisis than in the actual crisis period might be the role played by the central bank in flooding the market with huge amounts of liquidity and acting as the central counterparty in large parts of the money market (Bräuning and Fecht, 2012).

The banks' level of capitalization and liquidity has been an important and intensively discussed issue and problems of undercapitalization and insufficient liquidity have been addressed at the international level not only by Basel III, for example, but also at national and European levels by compelling banks to hold higher capital and liquidity buffers. Nevertheless we reveal another, so far broadly underexplored issue which plays a part in destabilizing interbank market stability, namely the banks' credit quality. In contrast to idiosyncratic capitalization and liquidity shocks, shocks regarding the banks' credit quality impair interbank relations not just from one side of the lending relationship but also from the other. On the one hand, creditor banks withdraw from the interbank market by reducing lending and, on the other hand, borrower banks are becoming less financed as well. Table 7 provides some detailed results on the interaction models' parameter estimates, where columns 1 and 2 depict shocks of the strength one, columns 3 and 4 show shocks of the strength four, and columns 5 and 6 contain shocks of the strength eight. In line with results on the banks' capitalization, idiosyncratic credit quality shocks affect borrower banks distinctly more during the crisis period than in the non-crisis period. And, similar to capitalization shocks, we see a looming effect of credit quality shocks first affecting the probability of continuing the interbank lending relation, and, since a slip of three deciles in the distribution of the underlying variable, an increasing reduction of interbank exposures starting with a lending cut of 11percentage points, which ultimately adds up to a reduction of more than 75 percentage points in the case of a severe idiosyncratic shock of the strength *eight*.[26]

4.3.2 Idiosyncratic Shocks and Relationship Banking

So far we have demonstrated that idiosyncratic shocks heavily disturb interbank lending relations and can potentially impair market stability itself. As in Section 4.2, one can ask whether relationship banking in the form of a longer and more intensive interbank relationship in the past can help to overcome the negative effects of idiosyncratic shocks. To answer this question, we further expand both steps of the baseline Heckman Correction

[26] These results are to some extent mirrored by the ones of the quadratic term models which show for creditor banks a convex and for borrower banks a more concave relationship between the non-performing loans to total loans ratio and interbank exposure indicating a decreasing effect for the former and an increasing effect for the latter.

models (3) and (6) by the interaction term (13), that is we interact the creditor and borrower bank-specific shocks with our relationship proxy variables.

In contrast to Cocco et al. (2009), Affinito (2012) and others who present empirical evidence that relationship banking indeed helped to overcome market turmoil in the recent financial crisis, our results show that hard information dominates soft information. Tables 8 to 10 show parameter estimates of the interaction term models, where columns 1 and 2 present the regression coefficients and columns 3 and 4 the corresponding marginal effects at representative values $(idiosyncratic\ shock = 1|0)$.[27]

Table 8 shows that the negative effects of a capital shock of the strength *five* cannot be undone either by a longer or a more intensive interbank relation in the past or even by reciprocal lending. It should be borne in mind that an idiosyncratic capital shock of that strength is the weakest possible shock that impairs interbank lending in general. Results of more severe shocks are analogous to those presented and imply that, in contrast to the literature on bank-firm customer relationships which predicts that banks ensure the availability of credit to customer firms when these firms are in trouble, does not hold in a bank-bank context. As the interbank market is able to distinguish between banks of different quality even in times of aggregate distress, hard information seems to dominate soft information.

Likewise, Table 9 presents results of the case where a creditor or a borrower bank is hit by an idiosyncratic liquidity shock of the strength one which represents a slip of one decile in the underlying variable's yearly distribution. Though we do not detect a significant positive effect of relationship banking in terms of a longer and more intensive relationship, we do again present some evidence that reciprocal lending has a number of benefits if the borrower bank has been hit by such an idiosyncratic liquidity shock. A one SD increase in reciprocal lending that is lending from the initial borrower bank B to the creditor bank C, increases interbank lending by between 6 and 13 percentage points in the first place.

[27] We report marginal effects at representative values only for cases where the idiosyncratic shock exhibits an interbank lending reduction for the first time, that is in its weakest definition.

The positive effect of reciprocal lending also shows up in cases where either the creditor or the borrower bank is hit by a shock regarding its credit quality (Table 10). As idiosyncratic shocks regarding the banks credit quality affect interbank lending from both sides of the interbank lending relationship, Panel A in Table 10 presents estimation results and the corresponding marginal effects of a credit quality shock of the strength *one* which affects creditor banks in particular and Panel B shows results of a shock the strength *five* when borrower banks also start to suffer from an exceptionally strong increase in their non-performing loans to assets ratio (*NPLR*). In this regard, a one SD increase in reciprocal lending increases interbank lending to the stressed borrowing bank by between 16 and 22 percentage points and by between 12 and 14 percentage points even when it is the creditor bank that is in stress.

All in all, results show that relationship banking is not distinctively capable of overcoming bank-specific, i.e. self-induced problems, as hard information seems to dominate. Only reciprocal lending does, to some extent, increase interbank lending activity, maybe due to signaling effects or maturity swaps.

5 ROBUSTNESS TESTS

We employ a broad range of sensitivity analyses to assess the robustness of our findings. In general, we conduct various robustness checks on our overall dataset, such as the level at which we correct for outliers, the overall sample that we analyze, and the utilized merger correction procedure. We also conduct checks on the definition of our main variables of interest and the models' distinct specification for testing.

5.1 OBSERVATIONS AND SAMPLE

We start with sensitivity analyses for the overall structure of our database. For the first set of control variables, namely bank characteristics, we delete outliers except for *Size* at the 1% level, but rerun our specifications without carrying out any outlier correction measures. In general, we utilize varying sets of control variables, such as alternative capital, liquidity and profitability ratios and specifications without bank group controls, or without any set of control variables at all. Regarding the sample size, we rerun the models for private banks only, that is without *Landesbanken*, savings and cooperative banks and central institutions of cooperative banks, as well for a sub-period since 2008 where we are able to utilize the banks' estimates of their counterparty's *probability of default (PD)*. Results qualitatively do not change. Finally, a number of bank mergers took place between the first quarter of 2000 to the third quarter of 2012. Therefore, we carry out a merger correction procedure by creating a new separate bank after the merger takes place. Generally, the duration of the relationships still amounts to nearly three years, which should be a sufficient amount of time to overcome asymmetric information due to relationship banking (Rochet & Tirole, 1996). Nevertheless, results are robust to alternative specifications.

5.2 VARIABLES OF INTEREST

5.2.1 RELATION, CRISIS AND RISK MEASURES

Second, regarding our main variables of interest, such as the relationship proxies, we use varying lags especially for those utilized in the baseline specification with contemporaneous values. Further, beyond splitting the aggregated crisis period into different sub-crisis periods like the commercial paper crisis (2007Q3 - 2008Q3), the Lehman crisis (2008Q4 - 2009Q4) and the euro crisis (2010Q1 - 2012Q3) and varying the starting points of these crises periods, we analyze a set of periods of special interest; for instance, periods in which the ECB switched its operational framework from a regular variable-rate tender procedure to a fixed-rate full allotment policy. Results show that in the full allotment period in 2008Q4 itself the likelihood of interbank participation drops significantly by between 1.6 and 7 percent, but we do not detect reduced interbank market exposures in that period or in the preceding quarters. Regarding the risk measure, we utilize not only the non-performing loans to total loans ratio (*NPLR*) but also the bank's Z-score, such as the bank's PD for a sub-period since 2008Q1.

5.2.2 Idiosyncratic Shocks

Above and beyond that, as we identify idiosyncratic shocks to be the most important determinants of interbank market stability, we examine a broad range of model specifications and modify the definition of an idiosyncratic shock in several ways. First, we redefine idiosyncratic shocks so that a shock is associated only with a drop into the second quartile of the distribution of the underlying shock variable. In other words, the shock dummy variable does not take the value one in those cases where the borrower or the creditor bank experiences a quarter-to-quarter slip, say, in their capital or liquidity ratio distribution from a high to a moderate point, but at least into the 50th percentile. Second, we extend our models by a dummy variable that takes the value one if a bank is already in the worst decile of the underlying variable's distribution, as those banks by definition do not exhibit an idiosyncratic shock. Results do not differ substantially from the ones presented; at the most, effects are to some extent even more pronounced. Finally, we examine the effect of quadratic terms, which do indeed display a non-linear behavior. For instance, we find a more concave risk-exposure relationship for borrower banks and a convex risk-exposure relationship for creditor banks, confirming an increasing effect of risk for borrower banks and a diminishing effect for creditor banks.

Alongside the main idiosyncratic shocks presented, which severely affect interbank relations and lending, we also examine shocks of creditor banks' and borrower banks' Z-scores, PD and profitability.[28] As in results of our baseline model in Section 4.1, lower profitability does not affect interbank stability at all. Even after extremely sharp declines in profitability from one quarter to another creditor banks do not reduce interbank lending nor

[28] See Appendix (available on request)

do borrower banks face problems in prolonging their interbank positions. Higher risk in terms of shocks regarding the banks' Z-score did not impair interbank relationships in the recent crisis either. Similar to liquidity shocks, results show a difference between the crisis and the non-crisis periods as lower Z-scores destabilize interbank lending more in the non-crisis period than in the actual crisis period. In fact, lower Z-scores only reduce interbank lending in the non-crisis period (Appendix Table A10). Results regarding higher probabilities of default are to some extent sketchy, as we only detect interbank exposure reductions of up to 7.4 percentage points after a creditor, or borrower PD shock of the size of one (Appendix Table A5). One possible explanation might give Behn et al. (2014), who show that the introduction of Basel II-type, model-based capital regulation affected the validity of banks' internal risk estimates. Also, results of the quadratic term model show a considerable decreasing effect of higher PDs for both creditor and borrower banks.

6 Conclusion

Though the importance of interbank relations for the distribution of liquidity is well recognized, the main drivers that foster the persistence and the strength of interbank relations – or trigger their collapse – are as yet unknown. In this study we present novel evidence of the microeconometric determinants of banks' bilateral positions. In particular, while existing research is mostly concerned with the effects of aggregate shocks, such as the 2007 commercial paper crisis or the Lehman insolvency, on the functioning of interbank relations, we focus on the so far underexplored importance of idiosyncratic bank shocks that is shocks with regard to distinct individual bank's balance sheet positions. By disentangling the effects and the inherently differing information content of aggregate and idiosyncratic shocks, we provide evidence of whether some banks' inability to roll over their interbank positions in the recent financial crisis was due to a failure of the interbank market in reallocating liquidity efficiently within the banking sector itself, i.e. a frozen interbank market, or rather to revised bank-level risk perceptions that lead to a stressed money market.

Our results clearly confirm the latter proposition. Though detecting a statistically significant but small reduction in the bank-to-bank exposures due to the crisis we clearly identify idiosyncratic shocks to be substantially more important for the recent disruptions on the interbank market. Indeed, banks avoid terminating interbank relationships, but, economically and statistically, they reduce their exposures based on hard information about their peers.

Moreover, identifying idiosyncratic shocks as the main driver disrupting interbank lending, we also analyze the effects of risk taking and reciprocal behavior on the banks' bilateral exposures and test whether relationship banking can outweigh the negative effects induced by bank-specific shocks. Unlike earlier studies which find that relationship banking helps to overcome financial instability, we show distinct evidence that, except reciprocal lending, this is not the case for the German interbank market. Neither longer nor more intense interbank relationships in the past contain the negative effects of either aggregate or idiosyncratic shocks regarding the banks' capital, credit quality or liquidity.

Summing up, our results show that the inability of some banks to roll over their interbank position and the ensuing financial market turmoil were not due to a failure of the interbank market *per se* but rather to bank-specific shocks affecting the banks' capital, liquidity and credit quality. Most importantly, the results uncover a so far undocumented ability of the interbank market to distinguish between banks of different quality in times of aggregate distress.

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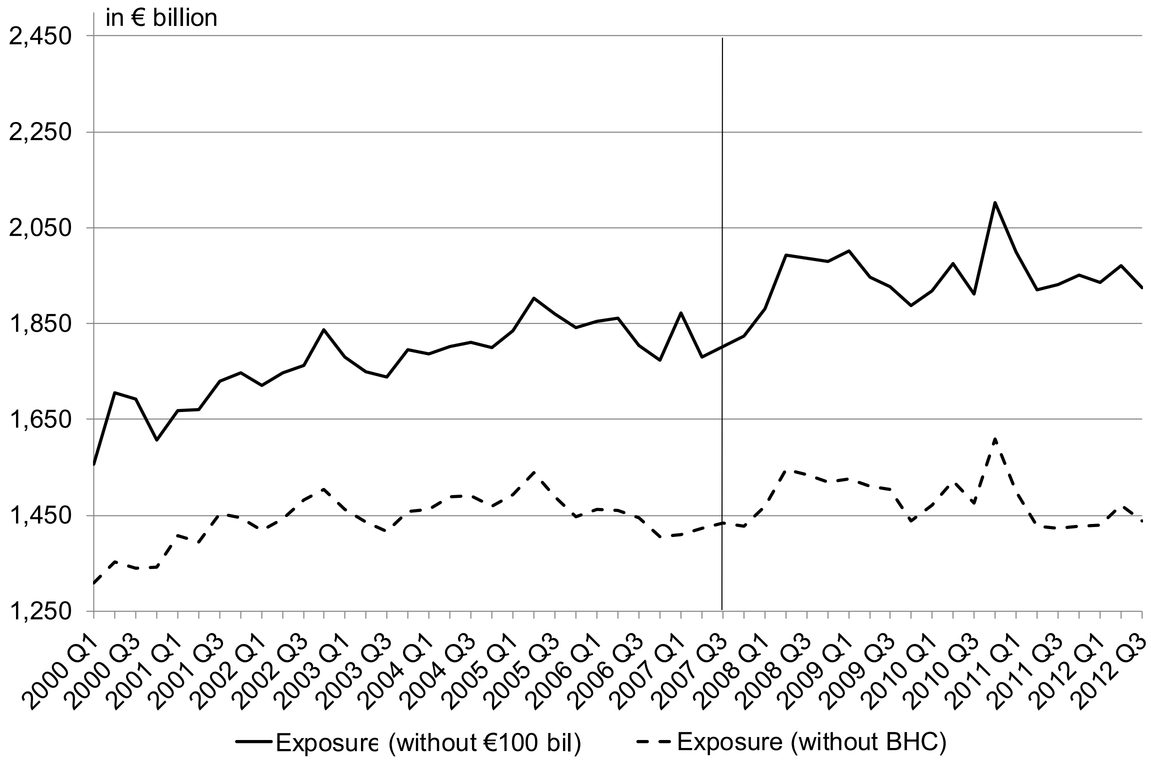
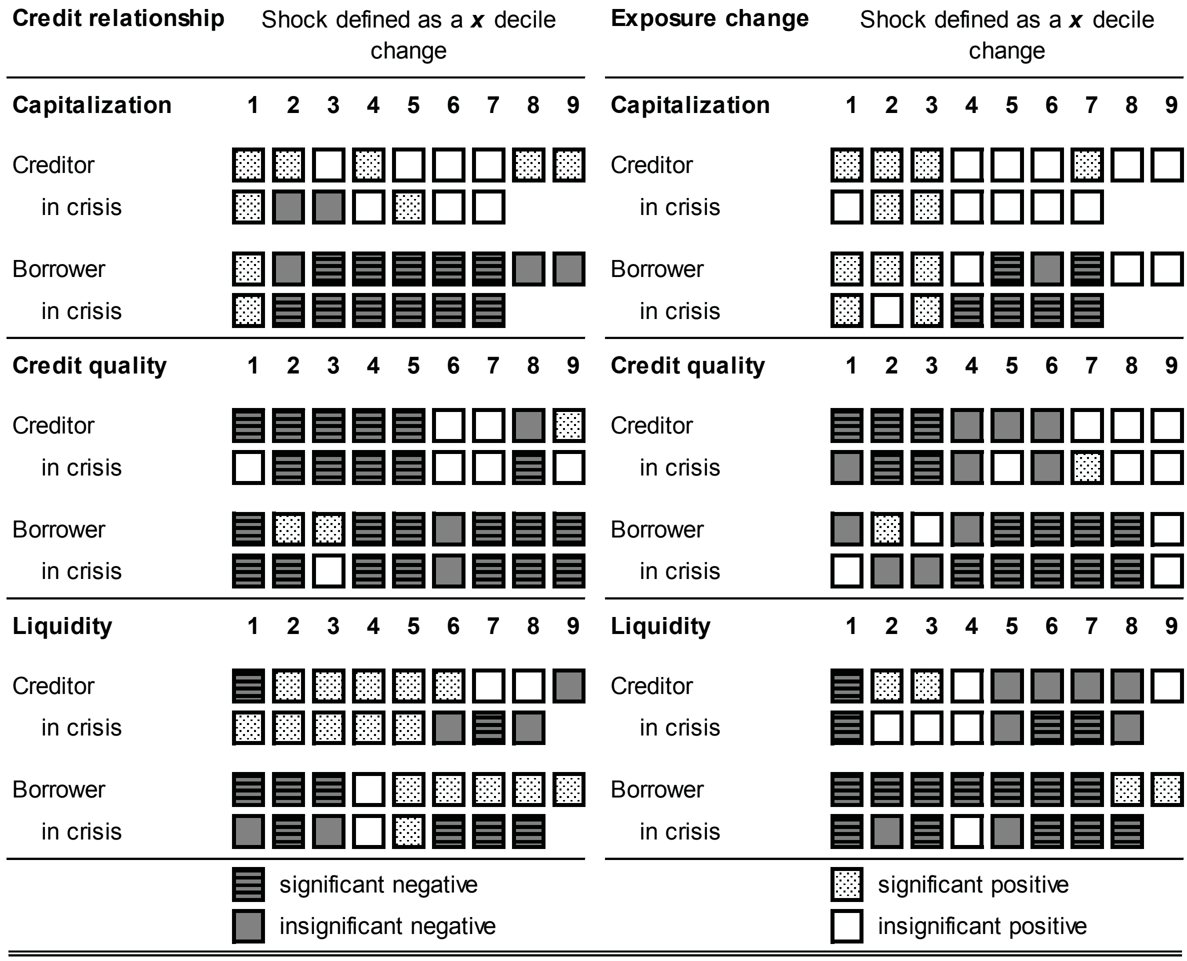
FIGURE 1 AGGREGATED INTERBANK LENDING



This figure shows the amount of quarterly interbank lending in a highly aggregated form, where the solid line depicts interbank exposures excluding quarterly bank to bank exposures of €100 billion and more and the dashed line shows aggregate interbank lending excluding exposures between banks belonging to the same BHC. The beginning of the aggregated crisis period is indicated by the vertical bar at 2007Q3. It is noteworthy that there is an upwards shift of excessive high bank-to-bank exposures of more than €100 billion since 2007Q3. All of these cases are conducted between parent banks and their affiliated mortgage banks. But as there is in some quarters of the crisis period only one such observation, we refrain from showing these data points. In general, excessive bank-to-bank exposures of more than €100 billion peak in 2008Q4 with an amount of €290 billion.

FIGURE 2 MAIN IDIOSYNCRATIC SHOCKS



This figure illustrates the parameter estimates of the baseline Heckman Two-Step Correction Model augmented by a creditor and borrower bank-specific shock and an interaction term of the idiosyncratic shock and the "Crisis" variable, which is a dummy variable that takes the value one from 2007Q3 onwards and zero otherwise. The bank-specific shock variable is an alternating dummy variable that takes the value one if there is a bad or unfavorable change in the distribution of the underlying shock variable of 1 (2,..., 9) decile(s) from one quarter to another and zero otherwise, whereas we portioned the distribution into 10 equal percentiles. In the first step of the Heckit Model, the left-hand side variable (LHS) is "Credit relationship", which is a dummy variable that takes the value one if there is a distinct credit relationship from a creditor bank C to a borrower bank B and zero otherwise. The LHS variable for the second step is "Exposure change" in log differences. For the the right-hand side variables (RHS) we use all variables of the baseline regression model augmented by the idiosyncratic shock variable and the interaction term between the shock and the "Crisis" variable. Generally, the left-hand side of the figure shows results of the first step of the Heckman selection method, and the right-hand side results of the second step. Parameter estimates of the idiosyncratic shock variables of the baseline Heckit model augmented by the those shock variables are presented in the first and third lines, respectively. Marginal effects at representative values (Crisis=1|0) of the idiosyncratic shock variables of the baseline model augmented by the interaction term are illustrated in the second and fourth lines marked by “in crisis”. The figure illustrates parameter estimates of idiosyncratic shocks regarding the creditor and borrower bank’s capitalization, credit quality and liquidity, while the dashed grey tiles represent significantly negative coefficients and the dotted white tiles significantly positive coefficients.

TABLE 1 DESCRIPTIVE STATISTICS

PANEL A	NUMBER OF ENTITIES	NUMBER OF OBSERVATIONS		NUMBER OF ENTITIES	NUMBER OF OBSERVATIONS
Banks			Credit relationships		4,618,586
Creditor	3,550		True		1,923,521
Borrower	3,494		BHC		29,837
			Reciproc relationships		822,016
			BHC		47,201
Big bank			Cooperative bank		
Creditor	5	112,596	Creditor	1,964	1,719,816
Borrower	5	334,371	Borrower	1,589	360,599
Regional bank			Private mortgage bank		
Creditor	285	394,470	Creditor	30	151,338
Borrower	263	520,512	Borrower	27	1,070,486
Subsidiary of a foreign bank			Public real estate credit agency		
Creditor	120	63,292	Creditor	4	5,089
Borrower	1	20	Borrower	4	19,910
Landesbank			Bank with special functions		
Creditor	15	336,343	Creditor	23	152,438
Borrower	15	682,815	Borrower	25	198,418
Savings bank			Foreign subsidiary of a German bank		
Creditor	573	1,047,458	Creditor	34	79,349
Borrower	533	469,381	Borrower	31	98,457
Cooperative Central Bank			Others		
Creditor	4	110,015	Creditor	528	140,162
Borrower	2	128,902	Borrower	1,032	304,261

Panel A of this table shows summary statistics regarding the number of banks, their distinct bank group and the number of bank quarter observations regarding those entities as well as the overall number of observations. In this regard, BHC refers to bank holding company. Panel B provides summary statistics of (reciprocal) interbank exposures, concentration measures as well as summary statistics regarding the duration (break) of bank-to-bank relationships. Concentration measures are the lender preference index "LPI", which is the the amount lent by a creditor bank C to a borrower bank B relative to the overall amount lent by bank C in any distinct quarter, and the borrower preference index "BPI", which is calculated as the amount borrowed by bank B from bank C relative to the overall borrowing by bank B, respectively. "Credit relation span" adds up the bank quarters of a creditor bank C providing continuous lending to a specific borrower bank B, "Reciproc relation span" captures the continous reverse lending from bank B to bank C and "Total relation ship span" adds up the quarters both banks C and B are related to each other in either direction. Panel C provides descriptive statistics about the most important bank characteristics, whereas each bank’s Z-score is calculated as the sum of the return on risk-wighted assets and the capital asset ratio divided by the return on risk-weighted assets’ standard deviation.

TABLE 1 CONTINUED

PANEL B	UNITS	NUMBER OF OBSERVATIONS	MEAN	STANDARD DEVIATION	5th PERCENTILE	MEDIAN	95th PERCENTILE
Exposure	m	1,923,521	51	938	0	5	143
Exposure change	%	1,820,018	0.2	4.8	-1.7	0	13.1
Reciproc exposure	m	822,016	86	1,390	0	6	281
LPI	%	1,923,521	6.1	15.4	0	1.5	30.9
BPI	%	1,923,521	6.3	19.9	0	0	55.6
Total relation span	levels	2,150,744	11.3	10.5	1	8	34
Credit relation span	levels	1,923,521	10.6	10	1	7	32
Reciproc relation span	levels	822,016	12.8	11.4	1	9	37
Total relation break	levels	2,467,842	11.7	10	1	9	33

PANEL C	UNITS	NUMBER OF OBSERVATIONS	MEAN	STANDARD DEVIATION	5th PERCENTILE	MEDIAN	95th PERCENTILE
Assets	m	109,140	3,610	29,800	39,3	378	6,530
Size	ln	109,140	19.9	1.6	17.5	19.8	22.6
CAPR	%	110,064	20.4	30.5	9.6	13.8	40.2
LAR	%	106,920	57.7	16.5	24.9	60.7	78.8
LIQR	%	101,818	21.5	11	9.7	19.3	40.4
ROA(rw)	%	107,632	1.2	6.5	-0.2	1.7	3.8
NPLR	%	109,669	4.1	3.4	0	3.6	10.1
Z-score	levels	102,057	31.8	20.5	5.1	29.5	68.3
PD	%	26,727	0.9	6.6	0.0	0.0	1.9

Panel A of this table shows summary statistics regarding the number of banks, their distinct bank group and the number of bank quarter observations regarding those entities as well as the overall number of observations. In this regard, BHC refers to bank holding company. Panel B provides summary statistics of (reciprocal) interbank exposures, concentration measures as well as summary statistics regarding the duration (break) of bank-to-bank relationships. Concentration measures are the lender preference index "LPI", which is the the amount lent by a creditor bank C to a borrower bank B relative to the overall amount lent by bank C in any distinct quarter, and the borrower preference index "BPI", which is calculated as the amount borrowed by bank B from bank C relative to the overall borrowing by bank B, respectively. "Credit relation span" adds up the bank quarters of a creditor bank C providing continuous lending to a specific borrower bank B, "Reciproc relation span" captures the continous reverse lending from bank B to bank C and "Total relation ship span" adds up the quarters both banks C and B are related to each other in either direction. Panel C provides descriptive statistics about the most important bank characteristics, whereas each bank’s Z-score is calculated as the sum of the return on risk-wighted assets and the capital asset ratio divided by the return on risk-weighted assets’ standard deviation.

Table 2 Description of Variables

Panel A	**Left-hand side (LHS)**	
Variable	*Description*	*Unit*
Credit relation	Dummy variable that takes the value one if there is a distinct credit relationship from a creditor bank C to a borrower bank B and zero otherwise.	0|1
Exposure change	$Exposure\ change_{CB_t} = ln(Exposure_{CB})_t - ln(Exposure_{CB})_{t-1}$	%
Lender Preference Index	$LPI_{CB_t} = \frac{Exposure_{CBt}}{\sum_B Exposure_{CBt}} * 100$	%
Borrower Preference Index	$BPI_{CB_t} = \frac{Exposure_{CBt}}{\sum_C Exposure_{CBt}} * 100$	%

Panel B	**Right-hand side (RHS)**	
Variable	*Description*	*Unit*
Crisis	Dummy variable that takes the value one from 2007Q3 onwards and zero otherwise.	0|1
Commercial Paper crisis	Dummy variable that takes the value one between 2007Q3 and 2008Q3 and zero otherwise.	0|1
Lehman crisis	Dummy variable that takes the value one between 2008Q4 and 2009Q4and zero otherwise.	0|1
Euro crisis	Dummy variable that takes the value one between 2010Q1 and 2012Q3 and zero otherwise.	0|1
Total relation span	Captures the interbank history of a specific pair of banks C and B by adding up the quarters these two banks have either a lending or borrowing relationship in quarter t.	levels
$Exposure_{t-1}$	Logarithm of the lagged exposure from the creditor bank C to the borrower bank B.	ln
Reciproc exposure	Reciprocal lending from the initial borrower bank B to the creditor bank C	ln
BHC dummy	Dummy variable for banks belonging to same bank holding company.	0|1
NPLR	Non-performing loans to total loans ratio	%
Z-score	$Z - score = \frac{ROA(rw) + CAPR}{SD(ROA(rw))}$	levels
PD	Median value of all creditor banks' C estimates on borrower bank's B probability of default.	%
Shock \`x'	The idiosyncratic shock variable is an alternating dummy variable that takes the value one if there is a bad respectively unfavorable change in the distribution of the underlying shock variable x (= CAPR, NPLR, LIQR, ROA(rw), PD and Z-score) of 1 (2,..., 9) decile(s) from one quarter to another and zero otherwise, whereas we portioned the distribution into 10 equal percentiles.	0|1
	Controls	
Size	Logarithm of total assets	ln
LAR	Loans to asset ratio (without interbank loans)	%
LIQR	Liquid assets to total assets ratio	%
CAPR	Regulatory capital ratio	%
ROA(rw)	Return on risk weighted assets	%
lambda	Heckman's lambda: Ratio between the standard normal probability density function ϕ and the standard normal cumulative distribution function Φ, each evaluated at observation k	
Bank group controls	Dummy variables classifying each bank in any distinct quarter into a specific bank group listed in Panel A of Table 1.	0|1

Panel A of this table presents our left-hand side (LHS) and Panel B a comprehensive list of varying right-hand side (RHS) variables.

TABLE 3 BASELINE

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
RHS / LHS	Credit relation		Exposure change		LPI		BPI	
Crisis	-0.159 ***	-	-0.037 **	-	0.473 ***	-	0.131 ***	-
	(-25.80)	-	(-2.47)	-	(10.82)	-	(5.33)	-
Commercial Paper crisis	-	-0.191 ***	-	-0.028 *	-	0.329 ***	-	0.110 ***
	-	(-27.70)	-	(-1.86)	-	(8.83)	-	(5.02)
Lehman crisis	-	-0.094 ***	-	0.017	-	0.656 ***	-	0.249 ***
	-	(-11.86)	-	(0.91)	-	(10.85)	-	(6.95)
Euro crisis	-	-0.174 ***	-	-0.135 ***	-	0.713 ***	-	-0.034
	-	(-20.72)	-	(-6.20)	-	(9.51)	-	(-0.73)
Total relation span	0.057 ***	0.057 ***	-0.009 ***	-0.008 ***	0.058 ***	0.055 ***	0.015 ***	0.017 ***
	(73.60)	(73.53)	(-13.29)	(-11.27)	(18.94)	(18.51)	(4.64)	(5.16)
Exposure $_{t-1}$	0.224 ***	0.224 ***	-0.220 ***	-0.220 ***	0.514 ***	0.514 ***	0.365 ***	0.365 ***
	(591.97)	(591.41)	(-35.87)	(-35.88)	(48.30)	(48.36)	(29.38)	(29.39)
Reciproc exposure	-0.012 ***	-0.012 ***	0.019 ***	0.019 ***	0.055 ***	0.055 ***	0.024 ***	0.024 ***
	(-16.26)	(-16.36)	(14.06)	(13.98)	(17.15)	(17.19)	(8.81)	(8.72)
BHC dummy	0.656 ***	0.655 ***	1.510 ***	1.511 ***	5.814 ***	5.812 ***	4.737 ***	4.741 ***
	(7.20)	(7.20)	(9.47)	(9.48)	(5.23)	(5.23)	(4.73)	(4.74)
Size creditor $_{t-1}$	0.148 ***	0.148 ***	0.063 ***	0.066 ***	-2.160 ***	-2.184 ***	1.232 ***	1.248 ***
	(50.70)	(50.63)	(6.85)	(7.20)	(-46.34)	(-46.33)	(15.00)	(15.09)
Size borrower $_{t-1}$	0.124 ***	0.124 ***	0.432 ***	0.433 ***	0.782 ***	0.773 ***	-1.433 ***	-1.426 ***
	(37.41)	(37.43)	(42.33)	(42.43)	(19.94)	(19.66)	(-31.36)	(-31.20)
LAR creditor $_{t-1}$	-0.001 ***	-0.001 ***	-0.022 ***	-0.022 ***	0.043 ***	0.043 ***	-0.019 ***	-0.019 ***
	(-5.16)	(-5.14)	(-29.39)	(-29.42)	(12.42)	(12.42)	(-8.13)	(-8.03)
LAR borrower $_{t-1}$	0.001 ***	0.001 ***	0.018 ***	0.018 ***	0.017 ***	0.015 ***	-0.022 ***	-0.022 ***
	(5.25)	(5.27)	(26.01)	(26.27)	(9.82)	(8.71)	(-7.60)	(-7.36)
LIQR creditor $_{t-1}$	0.005 ***	0.005 ***	-0.012 ***	-0.013 ***	0.047 ***	0.050 ***	-0.043 ***	-0.045 ***
	(15.89)	(15.50)	(-14.23)	(-15.32)	(14.16)	(14.86)	(-12.05)	(-12.65)
LIQR borrower $_{t-1}$	0.002 ***	0.002 ***	-0.012 ***	-0.013 ***	-0.014 ***	-0.011 ***	-0.008 ***	-0.010 ***
	(8.26)	(8.12)	(-15.79)	(-16.88)	(-6.31)	(-5.29)	(-2.88)	(-3.54)
CAPR creditor $_{t-1}$	-0.001 ***	-0.001 ***	-0.008 ***	-0.007 ***	0.005	0.002	0.006 ***	0.008 ***
	(-2.81)	(-2.76)	(-5.46)	(-4.72)	(0.50)	(0.17)	(2.60)	(3.23)
CAPR borrower $_{t-1}$	-0.003 ***	-0.003 ***	-0.015 ***	-0.014 ***	-0.026 ***	-0.030 ***	-0.016 ***	-0.014 ***
	(-6.69)	(-6.59)	(-11.54)	(-10.46)	(-8.49)	(-9.41)	(-3.39)	(-2.93)
ROA(rw) creditor $_{t-1}$	0.002	0.002	-0.002	-0.001	0.001	-0.006	-0.020 ***	-0.019 ***
	(1.59)	(1.51)	(-0.56)	(-0.31)	(0.05)	(-0.33)	(-3.27)	(-3.14)
ROA(rw) borrower $_{t-1}$	0.004 **	0.004 **	0.029 ***	0.030 ***	0.003	-0.003	0.043 ***	0.043 ***
	(2.30)	(2.24)	(5.71)	(5.82)	(0.39)	(-0.41)	(2.61)	(2.63)
lambda	-	-	5.668 ***	5.667 ***	4.254 ***	4.252 ***	2.953 ***	2.952 ***
	-	-	(112.74)	(112.69)	(45.49)	(45.58)	(28.96)	(28.98)
constant	-7.663 ***	-7.663 ***	-8.017 ***	-8.101 ***	20.472 ***	21.248 ***	0.936	0.420
	(-65.24)	(-65.22)	(-23.60)	(-23.81)	(13.91)	(14.27)	(0.43)	(0.19)
Bank group controls	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**
Obs	2,496,756	2,496,756	1,188,579	1,188,579	1,188,579	1,188,579	1,188,579	1,188,579
Pseudo R-squared	0.764	0.764	-	-	-	-	-	-
R-squared overall	-	-	0.35103	0.35116	0.61424	0.61415	0.70840	0.70837
R-squared between	-	-	0.34973	0.34984	0.53940	0.53914	0.67086	0.67076
R-squared within	-	-	0.50055	0.50050	0.02777	0.02812	0.02252	0.02276

z-statistic in parantheses
*p<0.10, **p<0.05, ***p<0.01

This table presents the estimation results of the baseline Heckman Two-Step Correction Model. In the first step, the left-hand side variable (LHS) is "Credit relationship" which is a dummy variable that takes the value one if there is a distinct credit relationship from a creditor bank C to a borrower bank B and zero otherwise (Column 1 and 2). The LHS variable for the second step is either "Exposure change" in log differences (Column 3 and 4), the lender preference index "LPI" (Column 5 and 6) or the borrower preference index "BPI" (7 and 8). The first group of right-hand side variables (RHS) capture the effects of the 2007 financial crisis period by two differect crisis specifications. Columns 1, 3, 5 and 7 show results of the aggregated crisis period, where the "Crisis" variable is a dummy variable that takes the value one from 2007Q3 onwards and zero otherwise. Columns 2, 4, 6 and 8 present results where the crisis period is split up into a "Commercial Paper crisis" (2007Q3-2008Q3), a "Lehman crisis" (2008Q4-2009Q4) and a "Euro crisis" period (2010Q1-2012Q3). The corresponding variables are dummy variables that take the value one in the definied period and zero otherwise. The second group of the RHS variables account for the banks' relationship intensity. "Total relation span" counts the number of sustained quarters bank C and bank B interact with each other, either as creditors or borrowers. "Exposure $_{t-1}$" is the log pre-quarter exposure from the creditor bank C to borrower bank B, "Reciproc exposure" is the log reciprocal exposure from bank B to bank C, and the "BHC dummy" variable takes the value one if both banks belong to same bank holding company and zero otherwise. The third group of the RHS variables control for bank characteristics. We use the banks' balance sheet items with a one quarter lag and delete spurious outliers at the 1 percent level except "Size" which is the banks' log assets. Finally, we account for the creditor's and borrower's distinct bank groups, respectively.

TABLE 4 INTERBANK RELATIONS & RISK IN TIMES OF AGGREGATE MARKET TURMOIL

PANEL A	(1)	(2)	(3)	(4)
RHS / LHS	Credit relation		Exposure change	
Crisis	0.010 *	-0.143 ***	-0.346 ***	0.028
	(1.66)	(-13.41)	(-6.85)	(1.28)
Total relation span	0.091 ***	0.058 ***	-0.007 ***	-0.008 ***
	(78.65)	(73.65)	(-8.48)	(-11.07)
ln Exposure (lagged)	0.220 ***	0.224 ***	-0.259 ***	-0.237 ***
	(492.61)	(553.74)	(-41.74)	(-36.97)
ln Reciproc exposure	-0.018 ***	-0.016 ***	0.013 ***	0.018 ***
	(-22.66)	(-19.69)	(8.94)	(12.75)
Crisis x Total relation span	-0.045 ***	-	-0.006 ***	-
	(-36.59)	-	(-5.85)	-
Crisis x Exposure $_{t-1}$	0.003 ***	-	0.019 ***	-
	(4.53)	-	(5.83)	-
Crisis x Reciproc exposure	0.001	-	0.011 ***	-
	(0.49)	-	(7.91)	-
NPLR creditor $_{t-4}$	-	-0.009 ***	-	-0.018 ***
	-	(-8.25)	-	(-5.88)
NPLR borrower $_{t-4}$	-	-0.009 ***	-	-0.010 ***
	-	(-8.08)	-	(-3.51)
Crisis x NPLR creditor $_{t-4}$	-	0.017 ***	-	0.007 *
	-	(9.14)	-	(1.81)
Crisis x NPLR borrower $_{t-4}$	-	-0.020 ***	-	-0.045 ***
	-	(-9.84)	-	(-10.48)
constant	-7.535 ***	-7.657 ***	-7.609 ***	-7.697 ***
	(-64.46)	(-61.74)	(-22.17)	(-21.35)
Baseline variables	**Yes**	**Yes**	**Yes**	**Yes**
Obs	2,496,756	2,302,387	1,188,579	1,095,082
Pseudo R-squared	0.767	0.769	-	-
R-squared overall	-	-	0.34881	0.35578
R-squared between	-	-	0.34602	0.34746
R-squared within	-	-	0.49959	0.50432

PANEL B	(1)	(2)	(3)	(4)
Marginal effects	Credit relation		Exposure change	
Total relation span				
at Crisis = 1	0.004 ***	-	-0.013 ***	-
	(53.04)	-	(-15.27)	-
at Crisis = 0	0.007 ***	-	-0.007 ***	-
	(83.50)	-	(-8.48)	-
Exposure $_{t-1}$				
at Crisis = 1	0.019 ***	-	-0.240 ***	-
	(241.06)	-	(-36.99)	-
at Crisis = 0	0.018 ***	-	-0.259 ***	-
	(285.09)	-	(-41.74)	-
Reciproc exposure				
at Crisis = 1	-0.002 ***	-	0.024 ***	-
	(-13.38)	-	(13.70)	-
at Crisis = 0	-0.002 ***	-	0.013 ***	-
	(-22.88)	-	(8.94)	-
NPLR creditor $_{t-1}$				
at Crisis = 1	-	0.001 ***	-	-0.010 ***
	-	(4.98)	-	(-2.90)
at Crisis = 0	-	-0.001 ***	-	-0.018 ***
	-	(-8.22)	-	(-5.88)
NPLR borrower $_{t-1}$				
at Crisis = 1	-	-0.002 ***	-	-0.055 ***
	-	(-15.62)	-	(-14.11)
at Crisis = 0	-	-0.001 ***	-	-0.010 ***
	-	(-8.09)	-	(-3.51)
Obs	2,496,756	2,302,387	1,188,579	1,095,082

z-statistic in parantheses
*p<0.10, **p<0.05, ***p<0.01

Panel A of this table presents the estimation results of the baseline Heckman Two-Step Correction Model augmented first by interaction terms between the aggregated "Crisis" variable and the bank-to-bank relationship proxies and second by interaction terms between the "Crisis" variable and a risk measure, namely the non-performing loans to asset ratio (NPLR) with a one year lag. The "Crisis" variable is a dummy variable that takes the value one from 2007Q3 onwards and zero otherwise. Panel B shows the marginal effects at representative values for these interaction term variables. In the first step of the Heckit Model, the left-hand side variable (LHS) is "Credit relationship", which is a dummy variable that takes the value one if there is a distinct credit relationship from a creditor bank C to a borrower bank B and zero otherwise (Columns 1 and 2 in Panel A and B). The LHS variable for the second step is "Exposure change" in log differences (Columns 3 and 4 in Panel A and B). For the the right-hand side variables (RHS) we use all variables of the baseline regression model augmented by the interaction terms described above.

TABLE 5 IDIOSYNCRATIC CAPITAL SHOCK X CRISIS

PANEL A	(1)	(2)	(3)	(4)	(5)	(6)
Shock definied as a	one decile change		two decile change		four decile change	
RHS / LHS	Credit relation	Exposure change	Credit relation	Exposure change	Credit relation	Exposure change
Crisis	-0.173 ***	-0.080 ***	-0.171 ***	-0.096 ***	-0.176 ***	-0.098 ***
	(-29.40)	(-5.62)	(-30.69)	(-6.94)	(-31.80)	(-7.13)
Shock CAPR creditor	0.035 ***	0.032 ***	0.060 ***	0.057 **	0.088 **	0.147
	(7.90)	(3.34)	(5.98)	(2.57)	(2.30)	(1.31)
Shock CAPR borrower	0.033 ***	0.089 ***	0.015 *	0.082 ***	-0.014	0.200 ***
	(7.70)	(9.68)	(1.77)	(4.07)	(-0.46)	(2.66)
Crisis x shock CAPR creditor	0.017 **	-0.013	-0.088 ***	0.026	-0.080	0.032
	(2.02)	(-0.78)	(-3.84)	(0.56)	(-0.92)	(0.15)
Crisis x shock CAPR borrower	-0.013	-0.048 ***	-0.094 ***	-0.054	-0.404 ***	-0.855 ***
	(-1.58)	(-2.71)	(-5.11)	(-1.36)	(-5.09)	(-2.77)
Baseline variables	**Yes**		**Yes**		**Yes**	
constant	-7.731 ***	-8.986 ***	-7.728 ***	-9.012 ***	-7.724 ***	-8.997 ***
	(-66.86)	(-26.83)	(-66.87)	(-26.90)	(-66.84)	(-26.86)
Obs	2,589,854	1,227,972	2,589,854	1,227,972	2,589,854	1,227,972
Pseudo R-squared	0.763	-	0.763	-	0.763	-
R-squared overall	-	0.35102	-	0.35111	-	0.35112
R-squared between	-	0.34545	-	0.34548	-	0.34548
R-squared within	-	0.50090	-	0.50097	-	0.50097

PANEL B	(1)	(2)	(3)	(4)	(5)	(6)
Marginal effects	Credit relation	Exposure change	Credit relation	Exposure change	Credit relation	Exposure change
Shock CAPR creditor						
at Crisis = 1	0.004 ***	0.019	-0.002	0.083 **	0.001	0.179
	(7.11)	(1.33)	(-1.38)	(2.01)	(0.11)	(1.00)
at Crisis = 0	0.003 ***	0.032 ***	0.006 ***	0.057 **	0.008 **	0.147
	(7.83)	(3.34)	(5.84)	(2.57)	(2.22)	(1.31)
Shock CAPR borrower						
at Crisis = 1	0.002 **	0.042 ***	-0.006 ***	0.027	-0.030 ***	-0.655 **
	(2.55)	(2.79)	(-4.93)	(0.79)	(-6.18)	(-2.19)
at Crisis = 0	0.003 ***	0.089 ***	0.001 *	0.082 ***	-0.001	0.200 ***
	(7.65)	(9.68)	(1.76)	(4.07)	(-0.46)	(2.66)
Obs	2,589,854	1,227,972	2,589,854	1,227,972	2,589,854	1,227,972

z-statistic in parantheses
*p<0.10, **p<0.05, ***p<0.01

Panel A of this table shows the estimation results of the baseline Heckman Two-Step Correction Model augmented by an interaction term of a creditor and borrower bank-specific shock and the "Crisis" variable, which is a dummy variable that takes the value one from 2007Q3 onwards and zero otherwise. The bank-specific shock variable is an alternating dummy variable that takes the value one if there is a bad or unfavorable change in the distribution of the underlying shock variable of 1 (2,..., 9) decile(s) from one quarter to another and zero otherwise, whereas we portioned the distribution into 10 equal percentiles. In the first step of the Heckit Model, the left-hand side variable (LHS) is "Credit relationship" which is a dummy variable that takes the value one if there is a distinct credit relationship from a creditor bank C to a borrower bank B and zero otherwise (Column 1, 3 and 5 of Panel A and B). The LHS variable for the second step is "Exposure change" in log differences (Column 2, 4 and 6 of Panel A and B). For the the right-hand side variables (RHS) we use all variables of the baseline regression model augmented by the interaction term between the idiosyncratic shock and the "Crisis" variable. Panel B shows the models' corresponding marginal effects at representative values whereas the table generally depicts estimation results of idiosyncratic shocks of the strengths one, two and four, that is an unfavourable change in the underlying variable's distribution from one quarter to another of one, two and four deciles, respectively.

TABLE 6 IDIOSYNCRATIC LIQUIDITY SHOCK X CRISIS

PANEL A	(1)	(2)	(3)	(4)	(5)	(6)
Shock definied as a	one decile change		two decile change		three decile change	
RHS / LHS	Credit relation	Exposure change	Credit relation	Exposure change	Credit relation	Exposure change
Crisis	-0.227 ***	-0.079 ***	-0.210 ***	-0.087 ***	-0.214 ***	-0.086 ***
	(-36.34)	(-5.53)	(-35.84)	(-6.33)	(-37.21)	(-6.32)
Shock LIQR creditor	0.036 ***	0.064 ***	0.142 ***	0.053 ***	0.145 ***	0.060 **
	(8.54)	(7.50)	(20.53)	(3.30)	(12.84)	(2.12)
Shock LIQR borrower	-0.065 ***	-0.161 ***	-0.052 ***	-0.201 ***	-0.075 ***	-0.438 ***
	(-11.80)	(-14.76)	(-5.16)	(-9.09)	(-3.94)	(-9.68)
Crisis x shock LIQR creditor	0.017 **	-0.092 ***	-0.083 ***	-0.040	-0.077 ***	-0.060
	(2.17)	(-6.39)	(-6.44)	(-1.62)	(-3.41)	(-1.34)
Crisis x shock LIQR borrower	0.055 ***	0.113 ***	-0.001	0.185 ***	0.065 **	0.328 ***
	(5.86)	(6.60)	(-0.08)	(5.75)	(2.14)	(4.81)
Baseline variables	**Yes**		**Yes**		**Yes**	
constant	-7.426 ***	-7.848 ***	-7.446 ***	-7.778 ***	-7.429 ***	-7.815 ***
	(-69.75)	(-23.99)	(-69.89)	(-23.74)	(-69.76)	(-23.84)
Obs	2,981,661	1,421,140	2,981,661	1,421,140	2,981,661	1,421,140
Pseudo R-squared	0.760	-	0.760	-	0.760	-
R-squared overall	-	0.35346	-	0.35314	-	0.35333
R-squared between	-	0.35820	-	0.35709	-	0.35823
R-squared within	-	0.50303	-	0.50289	-	0.50296

PANEL B	(1)	(2)	(3)	(4)	(5)	(6)
Marginal effects	Credit relation	Exposure change	Credit relation	Exposure change	Credit relation	Exposure change
Shock LIQR creditor						
at Crisis = 1	0.004 ***	-0.027 **	0.005 ***	0.012	0.006 ***	0.000
	(8.07)	(-2.37)	(5.20)	(0.65)	(3.42)	(0.01)
at Crisis = 0	0.003 ***	0.064 ***	0.014 ***	0.053 ***	0.014 ***	0.060 **
	(8.49)	(7.50)	(19.56)	(3.30)	(12.13)	(2.12)
Shock LIQR borrower						
at Crisis = 1	-0.001	-0.048 ***	-0.004 ***	-0.015	-0.001	-0.109 **
	(-1.27)	(-3.65)	(-4.02)	(-0.64)	(-0.40)	(-2.10)
at Crisis = 0	-0.006 ***	-0.161 ***	-0.005 ***	-0.201 ***	-0.007 ***	-0.438 ***
	(-12.03)	(-14.76)	(-5.26)	(-9.09)	(-4.05)	(-9.68)
Obs	2,981,661	1,421,140	2,981,661	1,421,140	2,981,661	1,421,140

z-statistic in parantheses
*p<0.10, **p<0.05, ***p<0.01

Panel A of this table shows the estimation results of the baseline Heckman Two-Step Correction Model augmented by an interaction term of a creditor and borrower bank-specific shock and the "Crisis" variable, which is a dummy variable that takes the value one from 2007Q3 onwards and zero otherwise. The bank-specific shock variable is an alternating dummy variable that takes the value one if there is a bad or unfavorable change in the distribution of the underlying shock variable of 1 (2,..., 9) decile(s) from one quarter to another and zero otherwise, whereas we portioned the distribution into 10 equal percentiles. In the first step of the Heckit Model, the left-hand side variable (LHS) is "Credit relationship" which is a dummy variable that takes the value one if there is a distinct credit relationship from a creditor bank C to a borrower bank B and zero otherwise (Column 1, 3 and 5 of Panel A and B). The LHS variable for the second step is "Exposure change" in log differences (Column 2, 4 and 6 of Panel A and B). For the the right-hand side variables (RHS) we use all variables of the baseline regression model augmented by the interaction term between the idiosyncratic shock and the "Crisis" variable. Panel B shows the models' corresponding marginal effects at representative values whereas the table generally depicts estimation results of idiosyncratic shocks of the strengths one, two and three that is an unfavourable change in the underlying variable's distribution from one quarter to another of one, two and three deciles, respectively.

TABLE 7 IDIOSYNCRATIC CREDIT QUALITY SHOCK X CRISIS

PANEL A	(1)	(2)	(3)	(4)	(5)	(6)
Shock definied as a	one decile change		four decile change		eight decile change	
RHS / LHS	Credit relation	Exposure change	Credit relation	Exposure change	Credit relation	Exposure change
Crisis	-0.162 ***	-0.050 ***	-0.151 ***	-0.029 **	-0.158 ***	-0.034 **
	(-23.77)	(-3.20)	(-24.39)	(-1.97)	(-25.53)	(-2.31)
Shock NPLR creditor	-0.028 ***	-0.071 ***	0.005	-0.103	0.127 **	-0.029
	(-4.97)	(-6.03)	(0.20)	(-1.64)	(2.34)	(-0.21)
Shock NPLR borrower	-0.005	-0.022 **	0.135 ***	0.300 ***	0.406 ***	0.351 **
	(-0.77)	(-1.97)	(4.86)	(6.15)	(3.32)	(2.16)
Crisis x shock NPLR creditor	0.029 ***	0.053 ***	-0.089 ***	0.100	-0.243 ***	0.158
	(3.09)	(3.12)	(-2.86)	(1.46)	(-2.85)	(0.87)
Crisis x shock NPLR borrower	-0.008	0.023	-0.267 ***	-0.410 ***	-0.619 ***	-1.127 ***
	(-0.86)	(1.43)	(-7.98)	(-7.39)	(-4.58)	(-5.31)
Baseline variables	**Yes**		**Yes**		**Yes**	
constant	-7.661 ***	-8.033 ***	-7.669 ***	-8.025 ***	-7.660 ***	-7.996 ***
	(-65.21)	(-23.65)	(-65.25)	(-23.61)	(-65.19)	(-23.54)
Obs	2,496,756	1,188,579	2,496,756	1,188,579	2,496,756	1,188,579
Pseudo R-squared	0.764	-	0.764	-	0.764	-
R-squared overall	-	0.35109	-	0.35093	-	0.35105
R-squared between	-	0.34978	-	0.34955	-	0.34974
R-squared within	-	0.50058	-	0.50053	-	0.50056

PANEL B	(1)	(2)	(5)	(6)	(7)	(8)
Marginal effects	Credit relation	Exposure change	Credit relation	Exposure change	Credit relation	Exposure change
Shock NPLR creditor						
at Crisis = 1	0.000	-0.017	-0.007 ***	-0.003	-0.009 *	0.128
	(0.15)	(-1.38)	(-4.32)	(-0.09)	(-1.77)	(1.08)
at Crisis = 0	-0.002 ***	-0.071 ***	0.000	-0.103	0.012 **	-0.029
	(-5.01)	(-6.03)	(0.20)	(-1.64)	(2.22)	(-0.21)
Shock NPLR borrower						
at Crisis = 1	-0.001 *	0.001	-0.010 ***	-0.110 ***	-0.016 ***	-0.775 ***
	(-1.75)	(0.11)	(-7.16)	(-4.09)	(-3.90)	(-5.60)
at Crisis = 0	-0.000	-0.022 **	0.013 ***	0.300 ***	0.044 ***	0.351 **
	(-0.78)	(-1.97)	(4.59)	(6.15)	(2.81)	(2.16)
Obs	2,496,756	1,188,579	2,496,756	1,188,579	2,496,756	1,188,579

z-statistic in parantheses
*p<0.10, **p<0.05, ***p<0.01

Panel A of this table shows the estimation results of the baseline Heckman Two-Step Correction Model augmented by an interaction term of a creditor and borrower bank-specific shock and the "Crisis" variable, which is a dummy variable that takes the value one from 2007Q3 onwards and zero otherwise. The bank-specific shock variable is an alternating dummy variable that takes the value one if there is a bad or unfavorable change in the distribution of the underlying shock variable of 1 (2,..., 9) decile(s) from one quarter to another and zero otherwise, whereas we portioned the distribution into 10 equal percentiles. In the first step of the Heckit Model, the left-hand side variable (LHS) is "Credit relationship" which is a dummy variable that takes the value one if there is a distinct credit relationship from a creditor bank C to a borrower bank B and zero otherwise (Column 1, 3 and 5 of Panel A and B). The LHS variable for the second step is "Exposure change" in log differences (Column 2, 4 and 6 of Panel A and B). For the the right-hand side variables (RHS) we use all variables of the baseline regression model augmented by the interaction term between the idiosyncratic shock and the "Crisis" variable. Panel B shows the models' corresponding marginal effects at representative values whereas the table generally depicts estimation results of idiosyncratic shocks of the strengths one, four and eight that is an unfavourable change in the underlying variable's distribution from one quarter to another of one, four and eight deciles, respectively.

TABLE 8 IDIOSYNCRATIC CAPITAL SHOCK X RELATIONSHIP

	(1)	(2)		(3)	(4)
Shock definied as a			five decile change		
RHS / LHS	Credit relation	Exposure change	**Marginal effects**	Credit relation	Exposure change
Crisis	-0.176 ***	-0.099 ***	Total relation span		
	(-31.91)	(-7.21)	at Shock Creditor = 1	0.013 ***	0.037
Shock CAPR creditor	-0.027	2.672 ***	at Shock Borrower = 1	(5.49)	(1.09)
	(-0.41)	(3.92)	at Shock Creditor = 1	0.014 ***	0.059 ***
Shock CAPR borrower	-0.175 ***	-0.706	at Shock Borrower = 0	(7.27)	(3.19)
	(-2.85)	(-1.14)	at Shock Creditor = 0	0.005 ***	-0.034
Total relation span	0.057 ***	-0.012 ***	at Shock Borrower = 1	(5.39)	(-1.20)
	(74.19)	(-18.81)	at Shock Creditor = 0	0.005 ***	-0.012 ***
ln Exposure (lagged)	0.224 ***	-0.216 ***	at Shock Borrower = 0	(75.35)	(-18.81)
	(599.89)	(-35.71)			
ln Reciproc exposure	-0.012 ***	0.019 ***	ln Exposure (lagged)		
	(-16.11)	(13.99)	at Shock Creditor = 1	0.015 ***	-0.388 ***
Shock CAPR creditor	0.102 ***	0.071 ***	at Shock Borrower = 1	(13.80)	(-6.46)
x Total relation span	(4.58)	(3.82)	at Shock Creditor = 1	0.016 ***	-0.445 ***
Shock CAPR borrower	0.003	-0.022	at Shock Borrower = 0	(16.68)	(-9.92)
x Total relation span	(0.28)	(-0.78)	at Shock Creditor = 0	0.017 ***	-0.159 ***
Shock CAPR creditor	-0.041 ***	-0.229 ***	at Shock Borrower = 1	(18.85)	(-3.93)
x ln Exposure (lagged)	(-3.55)	(-5.15)	at Shock Creditor = 0	0.019 ***	-0.216 ***
Shock CAPR borrower	0.000	0.056	at Shock Borrower = 0	(383.79)	(-35.71)
x ln Exposure (lagged)	(0.02)	(1.41)			
Shock CAPR creditor	-0.047 ***	-0.042 *	ln Reciproc exposure		
x ln Reciproc exposure	(-2.80)	(-1.68)	at Shock Creditor = 1	-0.004 **	-0.052
Shock CAPR borrower	0.007	-0.028	at Shock Borrower = 1	(-2.26)	(-1.34)
x ln Reciproc exposure	(0.47)	(-0.97)	at Shock Creditor = 1	-0.005 ***	-0.023
Baseline variables	**Yes**		at Shock Borrower = 0	(-3.40)	(-0.92)
constant	-7.725 ***	-8.993 ***	at Shock Creditor = 0	-0.000	-0.009
	(-66.86)	(-26.85)	at Shock Borrower = 1	(-0.37)	(-0.32)
			at Shock Creditor = 0	-0.001 ***	0.019 ***
Obs	2,589,854	1,227,972	at Shock Borrower = 0	(-16.17)	(13.99)
Pseudo R-squared	0.763	-			
R-squared overall	-	0.35113	Obs	2,589,854	1,227,972
R-squared between	-	0.34541			
R-squared within	-	0.50097			

z-statistic in parantheses
*p<0.10, **p<0.05, ***p<0.01

This table presents the estimation results of the baseline Heckman Two-Step Correction Model augmented by an interaction term of a creditor and borrower bank-specific shock and the relationship proxie variables as well as the interaction terms' corresponding marginal effects at representative values. The shock variable is an alternating dummy variable that takes the value one if there is a bad or unfavorable change in the distribution of the underlying shock variable of 1 (2,..., 9) decile(s) from one quarter to another and zero otherwise, whereas we portioned the distribution into 10 equal percentiles. Proxie variables that account for the banks' relationship intensity are as follows. "Total relation span" counts the number of sustained quarters bank C and bank B interact with each other, either as creditors or borrowers, "Exposure t - 1" is the log pre-quarter exposure from the creditor bank C to borrower bank B and "Reciproc exposure" is the log reciprocal exposure from bank B to bank C In the first step of the Heckit Model, the left-hand side variable (LHS) is "Credit relationship" which is a dummy variable that takes the value one if there is a distinct credit relationship from a creditor bank C to a borrower bank B and zero otherwise (Column 1 and 3). The LHS variable for the second step is "Exposure change" in log differences (Column 2 and 4). For the the right-hand side variables (RHS) we use all variables of the baseline regression model augmented by the interaction terms of the bank-specific shock variable and the relationship proxies whereas the table presents estimation results of an idiosyncratic shock of the strength five, that is an unfavourable change in the underlying variable's distribution from one quarter to another of five deciles.

TABLE 9 IDIOSYNCRATIC LIQUIDITY SHOCK X RELATIONSHIP

Shock definied as a one decile change

RHS / LHS	(1) Credit relation		(2) Exposure change	
Crisis	-0.214	***	-0.077	***
	(-37.42)		(-5.73)	
Shock LIQR creditor	0.065	***	0.511	***
	(16.19)		(15.22)	
Shock LIQR borrower	-0.011	**	-0.481	***
	(-2.17)		(-11.13)	
Total relation span	0.059	***	-0.007	***
	(77.56)		(-10.89)	
ln Exposure (lagged)	0.223	***	-0.213	***
	(561.53)		(-37.29)	
ln Reciproc exposure	-0.013	***	0.017	***
	(-17.67)		(13.25)	
Shock LIQR creditor	0.003	***	-0.004	***
x Total relation span	(3.13)		(-5.38)	
Shock LIQR borrower	-0.012	***	-0.002	**
x Total relation span	(-14.61)		(-2.52)	
Shock LIQR creditor	-0.001		-0.026	***
x ln Exposure (lagged)	(-1.11)		(-11.65)	
Shock LIQR borrower	0.001		0.023	***
x ln Exposure (lagged)	(1.22)		(8.28)	
Shock LIQR creditor	-0.014	***	-0.012	***
x ln Reciproc exposure	(-14.21)		(-13.03)	
Shock LIQR borrower	0.007	***	0.005	***
x ln Reciproc exposure	(7.62)		(5.04)	
Baseline variables	Yes			
constant	-7.441	***	-7.821	***
	(-69.88)		(-24.04)	
Obs	2,981,661		1,421,140	
Pseudo R-squared	0.760		-	
R-squared overall	-		0.35405	
R-squared between	-		0.35979	
R-squared within	-		0.50283	

Marginal effects	(3) Credit relation		(4) Exposure change	
Total relation span				
at Shock Creditor = 1	0.005	***	-0.013	***
at Shock Borrower = 1	(43.25)		(-11.92)	
at Shock Creditor = 1	0.006	***	-0.011	***
at Shock Borrower = 0	(59.85)		(-12.76)	
at Shock Creditor = 0	0.004	***	-0.009	***
at Shock Borrower = 1	(50.72)		(-9.80)	
at Shock Creditor = 0	0.005	***	-0.007	***
at Shock Borrower = 0	(78.41)		(-10.89)	
ln Exposure (lagged)				
at Shock Creditor = 1	0.020	***	-0.216	***
at Shock Borrower = 1	(199.15)		(-33.29)	
at Shock Creditor = 1	0.020	***	-0.239	***
at Shock Borrower = 0	(280.85)		(-40.55)	
at Shock Creditor = 0	0.019	***	-0.190	***
at Shock Borrower = 1	(226.82)		(-29.99)	
at Shock Creditor = 0	0.019	***	-0.213	***
at Shock Borrower = 0	(375.80)		(-37.29)	
ln Reciproc exposure				
at Shock Creditor = 1	-0.002	***	0.010	***
at Shock Borrower = 1	(-15.71)		(5.84)	
at Shock Creditor = 1	-0.002	***	0.005	***
at Shock Borrower = 0	(-25.53)		(3.14)	
at Shock Creditor = 0	-0.001	***	0.022	***
at Shock Borrower = 1	(-5.93)		(14.48)	
at Shock Creditor = 0	-0.001	***	0.017	***
at Shock Borrower = 0	(-17.71)		(13.25)	
Obs	2,981,661		1,421,140	

z-statistic in parantheses
*p<0.10, **p<0.05, ***p<0.01

This table presents the estimation results of the baseline Heckman Two-Step Correction Model augmented by an interaction term of a creditor and borrower bank-specific shock and the relationship proxie variables as well as the interaction terms' corresponding marginal effects at representative values. The shock variable is an alternating dummy variable that takes the value one if there is a bad or unfavorable change in the distribution of the underlying shock variable of 1 (2,..., 9) decile(s) from one quarter to another and zero otherwise, whereas we portioned the distribution into 10 equal percentiles. Proxie variables that account for the banks' relationship intensity are as follows. "Total relation span" counts the number of sustained quarters bank C and bank B interact with each other, either as creditors or borrowers, "Exposure t - 1" is the log pre-quarter exposure from the creditor bank C to borrower bank B and "Reciproc exposure" is the log reciprocal exposure from bank B to bank C In the first step of the Heckit Model, the left-hand side variable (LHS) is "Credit relationship" which is a dummy variable that takes the value one if there is a distinct credit relationship from a creditor bank C to a borrower bank B and zero otherwise (Column 1 and 3). The LHS variable for the second step is "Exposure change" in log differences (Column 2 and 4). For the the right-hand side variables (RHS) we use all variables of the baseline regression model augmented by the interaction terms of the bank-specific shock variable and the relationship proxies whereas the table presents estimation results of an idiosyncratic shock of the strength one, that is an unfavourable change in the underlying variable's distribution from one quarter to another of one decile.

TABLE 10 IDIOSYNCRATIC CREDIT QUALITY SHOCK X RELATIONSHIP

PANEL A	(1)	(2)		(3)	(4)
Shock definied as a			one decile change		
RHS / LHS	Credit relation	Exposure change	**Marginal effects**	Credit relation	Exposure change
Crisis	-0.157 ***	-0.033 **	Total relation span		
	(-25.41)	(-2.23)	at Shock Creditor = 1	0.004 ***	-0.008 ***
Shock NPLR creditor	0.013 **	-0.007	at Shock Borrower = 1	(41.03)	(-8.31)
	(2.48)	(-0.17)	at Shock Creditor = 1	0.004 ***	-0.009 ***
Shock NPLR borrower	0.024 ***	0.114 ***	at Shock Borrower = 0	(49.55)	(-10.21)
	(4.68)	(2.67)	at Shock Creditor = 0	0.005 ***	-0.008 ***
Total relation span	0.061 ***	-0.009 ***	at Shock Borrower = 1	(53.87)	(-9.59)
	(69.16)	(-12.49)	at Shock Creditor = 0	0.005 ***	-0.009 ***
In Exposure (lagged)	0.224 ***	-0.217 ***	at Shock Borrower = 0	(70.80)	(-12.49)
	(514.45)	(-35.16)			
In Reciproc exposure	-0.013 ***	0.018 ***	In Exposure (lagged)		
	(-15.86)	(12.57)	at Shock Creditor = 1	0.020 ***	-0.233 ***
Shock NPLR creditor	-0.011 ***	-0.000	at Shock Borrower = 1	(189.75)	(-34.29)
x Total relation span	(-12.81)	(-0.15)	at Shock Creditor = 1	0.020 ***	-0.222 ***
Shock NPLR borrower	-0.003 ***	0.001	at Shock Borrower = 0	(230.68)	(-33.76)
x Total relation span	(-2.96)	(1.28)	at Shock Creditor = 0	0.019 ***	-0.228 ***
Shock NPLR creditor	0.002 ***	-0.005 *	at Shock Borrower = 1	(228.58)	(-35.21)
x In Exposure (lagged)	(2.76)	(-1.75)	at Shock Creditor = 0	0.019 ***	-0.217 ***
Shock NPLR borrower	-0.002 ***	-0.011 ***	at Shock Borrower = 0	(334.70)	(-35.16)
x In Exposure (lagged)	(-3.00)	(-3.97)			
Shock NPLR creditor	0.007 ***	0.003 ***	In Reciproc exposure		
x In Reciproc exposure	(6.07)	(2.98)	at Shock Creditor = 1	-0.001 ***	0.023 ***
Shock NPLR borrower	-0.005 ***	0.003 **	at Shock Borrower = 1	(-7.96)	(12.89)
x In Reciproc exposure	(-4.39)	(2.42)	at Shock Creditor = 1	-0.001 ***	0.021 ***
Baseline variables	**Yes**		at Shock Borrower = 0	(-5.37)	(12.46)
constant	-7.662 ***	-8.083 ***	at Shock Creditor = 0	-0.002 ***	0.020 ***
	(-65.14)	(-23.78)	at Shock Borrower = 1	(-15.00)	(12.72)
			at Shock Creditor = 0	-0.001 ***	0.018 ***
Obs	2,496,756	1,188,579	at Shock Borrower = 0	(-15.95)	(12.57)
Pseudo R-squared	0.764	-			
R-squared overall	-	0.35103	Obs	2,496,756	1,188,579
R-squared between	-	0.34973			
R-squared within	-	0.50047			

z-statistic in parantheses
*p<0.10, **p<0.05, ***p<0.01

This table presents the estimation results of the baseline Heckman Two-Step Correction Model augmented by an interaction term of a creditor and borrower bank-specific shock and the relationship proxie variables as well as the interaction terms' corresponding marginal effects at representative values. The shock variable is an alternating dummy variable that takes the value one if there is a bad or unfavorable change in the distribution of the underlying shock variable of 1 (2,..., 9) decile(s) from one quarter to another and zero otherwise, whereas we portioned the distribution into 10 equal percentiles. Proxie variables that account for the banks' relationship intensity are as follows. "Total relation span" counts the number of sustained quarters bank C and bank B interact with each other, either as creditors or borrowers, "Exposure t - 1" is the log pre-quarter exposure from the creditor bank C to borrower bank B and "Reciproc exposure" is the log reciprocal exposure from bank B to bank C In the first step of the Heckit Model, the left-hand side variable (LHS) is "Credit relationship" which is a dummy variable that takes the value one if there is a distinct credit relationship from a creditor bank C to a borrower bank B and zero otherwise (Column 1 and 3). The LHS variable for the second step is "Exposure change" in log differences (Column 2 and 4). For the the right-hand side variables (RHS) we use all variables of the baseline regression model augmented by the interaction terms of the bank-specific shock variable and the relationship proxies whereas the table presents in Panel A estimation results of an idiosyncratic shock of the strength one, that is an unfavourable change in the underlying variable's distribution from one quarter to another of one decile and in Panel B results of an idiosyncratic shocks of the strength five.

TABLE 10 CONTINUED

PANEL B	(1)	(2)		(3)	(4)
Shock definied as a			five decile change		
RHS / LHS	Credit relation	Exposure change	**Marginal effects**	Credit relation	Exposure change
Crisis	-0.157 ***	-0.032 **	Total relation span		
	(-25.40)	(-2.13)	at Shock Creditor = 1	0.004 ***	-0.003
Shock NPLR creditor	0.050 **	-0.536 ***	at Shock Borrower = 1	(12.05)	(-0.78)
	(2.45)	(-3.47)	at Shock Creditor = 1	0.004 ***	-0.004
Shock NPLR borrower	-0.035	-0.260	at Shock Borrower = 0	(16.82)	(-1.27)
	(-1.59)	(-1.40)	at Shock Creditor = 0	0.005 ***	-0.009 ***
Total relation span	0.057 ***	-0.009 ***	at Shock Borrower = 1	(18.86)	(-2.93)
	(73.24)	(-13.57)	at Shock Creditor = 0	0.005 ***	-0.009 ***
ln Exposure (lagged)	0.224 ***	-0.221 ***	at Shock Borrower = 0	(74.37)	(-13.57)
	(589.39)	(-36.19)			
ln Reciproc exposure	-0.012 ***	0.019 ***	ln Exposure (lagged)		
	(-15.97)	(13.96)	at Shock Creditor = 1	0.019 ***	-0.191 ***
Shock NPLR creditor	-0.010 ***	0.006 **	at Shock Borrower = 1	(41.09)	(-11.64)
x Total relation span	(-3.65)	(2.12)	at Shock Creditor = 1	0.020 ***	-0.189 ***
Shock NPLR borrower	0.003	0.000	at Shock Borrower = 0	(59.60)	(-16.09)
x Total relation span	(1.12)	(0.11)	at Shock Creditor = 0	0.018 ***	-0.223 ***
Shock NPLR creditor	0.003	0.032 ***	at Shock Borrower = 1	(55.60)	(-16.87)
x ln Exposure (lagged)	(0.86)	(3.20)	at Shock Creditor = 0	0.019 ***	-0.221 ***
Shock NPLR borrower	-0.002	-0.002	at Shock Borrower = 0	(379.45)	(-36.19)
x ln Exposure (lagged)	(-0.55)	(-0.14)			
Shock NPLR creditor	-0.007	-0.009 **	ln Reciproc exposure		
x ln Reciproc exposure	(-1.59)	(-2.09)	at Shock Creditor = 1	-0.003 ***	0.026 ***
Shock NPLR borrower	-0.017 ***	0.017 ***	at Shock Borrower = 1	(-5.31)	(4.09)
x ln Reciproc exposure	(-3.34)	(3.68)	at Shock Creditor = 1	-0.002 ***	0.010 **
Baseline variables	**Yes**		at Shock Borrower = 0	(-4.24)	(2.12)
constant	-7.664 ***	-8.007 ***	at Shock Creditor = 0	-0.002 ***	0.036 ***
	(-65.28)	(-23.57)	at Shock Borrower = 1	(-5.67)	(7.56)
			at Shock Creditor = 0	-0.001 ***	0.019 ***
Obs	2,496,756	1,188,579	at Shock Borrower = 0	(-16.04)	(13.96)
Pseudo R-squared	0.764	-			
R-squared overall	-	0.35098	Obs	2,496,756	1,188,579
R-squared between	-	0.34967			
R-squared within	-	0.50053			

z-statistic in parantheses

*p<0.10, **p<0.05, ***p<0.01

This table presents the estimation results of the baseline Heckman Two-Step Correction Model augmented by an interaction term of a creditor and borrower bank specific shock and the relationship proxie variables as well as the interaction terms' corresponding marginal effects at representative values. The shock variable is an alternating dummy variable that takes the value one if there is a bad respectively unfavorable change in the distribution of the underlying shock variable of 1 (2,..., 9) decile(s) from one quarter to another and zero otherwise, whereas we portioned the distribution into 10 equal percentiles. Proxie variables that account for the banks' relationship intensity are as follows. "Total relation span" counts the number of sustained quarters bank C and bank B interact with each other, either as creditors or borrowers, "Exposure t - 1" is the log pre-quarter exposure from the creditor bank C to borrower bank B and "Reciproc exposure" is the log reciprocal exposure from bank B to bank C In the first step of the Heckit Model, the left hand side variable (LHS) is "Credit relationship" which is a dummy variable that takes the value one if there is a distinct credit relationship from a creditor bank C to a borrower bank B and zero otherwise (Column 1 and 3). The LHS variable for the second step is "Exposure change" in log differences (Column 2 and 4). For the the right hand side variables (RHS) we use all variables of the baseline regression model augmented by the interaction terms of the bank-specific shock variable and the relationship proxies whereas the table presents in Panel A estimation results of an idiosyncratic shock the strength one, that is an unfavourable change in the underlying variable's distribution from one quarter to another of one decile and in Panel B results of an idiosyncratic shock the strength five.