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## Repo funding and internal capital markets in the financial crisis

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## **Non-technical summary**

This paper examines to what extent the bank-internal fund management of German multinational banks was affected by the run on sale and repurchase (repo) markets which accelerated the development and worldwide transmission of the crisis.

Multinational banks manage their bank-internal funds globally, while the parent bank acts as the decision-making entity and coordinates liquidity support to its foreign affiliates. In many of the banks' entities established abroad, such funding through the internal capital market provides the finances for a considerable part of their operations. Balance sheet data at the levels of German parent banks, their foreign branches and their foreign subsidiaries are used in this paper to track the transmission of a funding shock to the internal capital market. Owing to the fact that they rely more strongly than does the rest of the banking organization on repo funding, German parent banks were particularly affected by the deteriorating lending conditions on these short-term refinancing markets. This paper demonstrates that, in the wake of the funding shock, parent banks started to withdraw and redirect liquidity within their banking organizations. The more parent banks were exposed to the run on repo markets provoked by the subprime market collapse, the Bear Stearns rescue and the Lehman Brothers bankruptcy, the more they limited the funds allocated to their foreign affiliates. Highly exposed parent banks were nevertheless able to shelter their foreign affiliates from the funding shock, the more they were able signal stability to the market by means of a strong equity capital base.

This study furthermore reveals substantial differences in bank-internal fund management when comparing the roles played by branches and subsidiaries as well as with regard to the various episodes of the financial crisis. The greater was the branches' responsibility within the banking organization for the provision of loans to the foreign non-bank private sector, the more parent banks protected branches. Liquidity was, however, withdrawn from subsidiaries, the stronger their standing in their respective local funding market. The allocation of such roles reflects the fact that German banks' foreign branches are often the main pillar for the lending business with foreign firms. German banks' foreign branches were consequently protected in times of distress, despite the fact that their consolidation into the parent banks' balance sheets facilitates the withdrawal of funds. Compared with branches, subsidiaries have more often established a larger

network of local depositors and investors as these are independent legal entities. Accordingly, the multinational banks took recourse to their funding strength in times of crisis. This clear pattern in the fund management of German multinational banks disappeared, however, as the financial crisis progressed. It is possible that the scope for protecting branches in major lending locations narrowed and that the ability to withdraw funds from subsidiaries became limited due to their obligation to fulfill local regulatory requirements.

Among the three events which triggered the loss of confidence in repo markets, the failure of Bear Stearns led, on average, to the largest withdrawal of funds from foreign affiliates in response to the funding shock experienced by their respective parent banks. The bankruptcy of Lehman Brothers prompted fewer reallocations of funds on internal capital markets towards the parent bank. Possibly, following the earlier shock event, banks had become willing or able to replace repo funding with other short-term funding sources. Most likely, rescue measures, such as the expansion of the Eurosystem's collateral framework, helped to ease the pressure on banks that had relied heavily on secured short-term funding and were strongly affected by the unexpected deterioration of this market. All in all, the results demonstrate that the rapid spreading of the financial crisis occurred both via short-term funding on interbank markets as well as via bank-internal capital markets.

## Nichttechnische Zusammenfassung

Diese Studie untersucht, inwiefern der Run auf Repomärkte (Wertpapierpensionsgeschäfte mit Rückkaufvereinbarung), der die Entwicklung und weltweite Ausbreitung der Finanzkrise beschleunigte, sich auf das interne Finanzierungsmanagement deutscher multinationaler Banken auswirkte.

In multinationalen Banken koordinieren die Muttergesellschaften das globale Finanzierungsmanagement und damit auch die Bereitstellung von Liquidität an ihre Niederlassungen im Ausland. Bei vielen Auslandsniederlassungen finanzieren diese Zuwendungen über den bankinternen Kapitalmarkt einen Großteil der Geschäftstätigkeit. In dieser Studie werden auf Bankebene Informationen über Bilanzpositionen deutscher Mutterbanken sowie ihrer ausländischen Zweigstellen und Töchter verwendet, um die Transmission eines Finanzierungsschocks über den bankinternen Kapitalmarkt zu analysieren. Deutsche Mutterbanken waren aufgrund ihrer verhältnismäßig stärkeren Nutzung in höherem Maße als andere Konzernteile vom Schrumpfen der Repomärkte betroffen. Die Analysen zeigen, dass die Mutterbanken als Reaktion auf den Finanzierungsschock Liquidität von ihren Auslandsniederlassungen abzogen und innerhalb des Bankkonzerns gemäß ihrer Prioritätensetzung umverteilten. Je stärker eine Mutterbank den Verwerfungen auf Repomärkten ausgesetzt war, die durch den Zusammenbruch des Subprime-Marktes sowie den Insolvenzen von Bear Stearns und Lehman Brothers wesentlich bestimmt wurden, desto eher reduzierte sie den Grad zu dem ihre Auslandsniederlassungen bankintern finanziert wurden. Die Transmission des Finanzierungsschocks über diesen Kanal konnte jedoch abgeschwächt werden, je eher die Mutterbank durch eine solide Eigenkapitalbasis dem Markt ihre Solvabilität signalisierte.

Über diese Ergebnisse hinaus zeigt die Studie, dass im bankinternen Finanzierungsmanagement während der Finanzkrise Zweigstellen und Töchter unterschiedliche Rollen spielten, und dass diese Rollenverteilung von der Zuspitzung der Finanzkrise beeinflusst war. Mutterbanken ließen ihren Zweigstellen stärkere Unterstützung zukommen je bedeutender diese innerhalb des Konzerns für die Kreditvergabe an den ausländischen Nichtbanken-Privatsektor waren. Von ausländischen Tochterbanken wurden dagegen umso mehr finanzielle Mittel abgezogen, je stärker sie sich in ihrem lokalen Umfeld refinanzierten. Diese Rollenverteilung spiegelt die Eigenschaft

der Zweigstellen als tragende Säulen des ausländischen Kreditgeschäfts deutscher Banken wider. In dieser Funktion wurden sie daher auch in Krisenzeiten gestützt, obwohl ihre Konsolidierung in die Bilanz der Mutterbank den Abzug von Liquidität erleichtert. Ausländische Töchter finanzieren sich anders als Zweigstellen stärker lokal, da sie als eigenständige Banken oft über ein größeres Netzwerk an lokalen Deponenten und Investoren verfügen. Diese Eigenschaft machten sich die Konzerne in Krisenzeiten zunutze. Mit Andauern der Krise verloren Mutterbanken jedoch den finanziellen Spielraum, der ihnen die Unterstützung wichtiger Zweigstellen ermöglichte. Daneben schränkte die Verpflichtung der Töchter, lokale regulatorische Auflagen zu erfüllen, zunehmend die Möglichkeit ein, Liquidität abzuziehen.

Im Vergleich der drei Schlüsselereignisse, die das Vertrauen in Repomärkte erschütterten, führte die Schieflage und anschließende Rettung von Bear Stearns im Durchschnitt zu den volumemäßig größten Kürzungen der finanziellen Unterstützung von Auslandsniederlassungen durch ihre jeweilige Mutterbank. Die Insolvenz von Lehman Brothers führte anschließend am bankinternen Kapitalmarkt zu geringerer Reallokation finanzieller Mittel. Möglicherweise waren die Banken nach dem vorhergegangenen Schock willens oder in der Lage, ihre Repofinanzierung anderweitig zu ersetzen. Es ist naheliegend, dass regulatorische Nofallmaßnahmen wie die Ausweitung des Sicherheitenrahmens im Eurosystem zusätzlich den Druck von Banken nahmen, die in hohem Maße auf diese besicherte Kurzfristfinanzierung vertraut hatten, und die daher stärker von den unerwartet starken Verwerfungen getroffen wurden. Insgesamt zeigt die Studie, dass die rasche Ausbreitung der Finanzkrise ihren Weg sowohl über kurzfristige Finanzierung auf dem Interbankenmarkt als auch über den bankinternen Kapitalmarkt fand.

# Repo funding and internal capital markets in the financial crisis\*

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## Abstract

This paper examines how the exposure of German parent banks to the disruptions on sale and repurchase markets (repo markets) during the financial crisis has affected their provision of funds to their foreign branches and subsidiaries via bank-internal capital markets. The collapse of the subprime market, the rescue of Bear Stearns and the bankruptcy of Lehman Brothers are analyzed with regard to their role as amplifiers of uncertainty about the value of collateral used in repo transactions and mistrust among market participants. The results show that parent banks which were more exposed to these disruptions were more likely to withdraw bank-internal funds from their branches and subsidiaries located abroad. Among the three events, the rescue of Bear Stearns triggered the largest contraction on internal capital markets from the part of the parent bank, possibly because this event demonstrated for the first time the fragility of even very large financial institutions. After the subprime market collapse, branches were briefly more protected as core investment locations, while subsidiaries were used as core funding locations up to the Lehman Brothers bankruptcy. All in all, funding via repo markets is found to be one channel that transmitted shocks primarily related to the US financial system abroad.

**Keywords:** Repo, funding structure, multinational banks, internal capital market, intra-bank lending, financial crisis.

**JEL Classification:** G21, G15, F34, E44

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# 1 Introduction

In the run-up to the financial crisis, the interconnectedness of financial institutions and excessive risk-taking worldwide were underestimated (MISHKIN (2011)). Recent literature has highlighted the role of globally active banks in transmitting the crisis, which began with the collapse of the US subprime housing market and spread to the global financial system. CETORELLI AND GOLDBERG (2012) document that US global banks activated their internal capital market in order to reallocate liquidity within their banking organizations, putting the needs of the parent bank first and, in some cases, using their foreign affiliates as sources of funding. In Europe, it was first believed that the subprime crisis was a market-specific crisis that would be confined to within the borders of the United States or disappear with the write-down of loans and the adjustments in the value of the collateral directly linked to the US subprime market, if not sooner. In stark contrast to such expectations, the disruptions in the US financial system triggered a worldwide financial crisis that continued to escalate for more than two years following the collapse of the subprime market in mid-2007. Such severe consequences would not have been possible without further transmission channels besides the direct exposure of banks around the world to the US subprime market. Referring to the interconnectedness of banks, GORTON AND METRICK (2012) argue that securitized banking was the key financial market instrument that aggravated the crisis and transmitted it to the rest of the world. This type of short-term refinancing on capital markets uses securitized assets as collateral in sale and repurchase (repo) transactions, and was believed to be more stable than unsecured funding. However, during the crisis, uncertainty about the value of the offered collateral and mistrust among market participants increased sharply, which severely limited the liquidity of these markets.

Using confidential data on German multinational banks, this paper analyzes how the exposure of these banks to the disruptions in securitized banking affected their global fund management. Three key events are analyzed with regard to their role in accelerating the loss of confidence and the deterioration of collateral value in this market: the collapse of the subprime market, the rescue of Bear Stearns, and the bankruptcy of Lehman Brothers. The study tests to what extent the vulnerability of parent banks to the drying-up of repo markets following these events reduced their support of affiliated banks abroad. By inspecting these changes on the banks'

internal capital markets, the paper asks whether the decisions taken by a parent bank regarding its global fund management are related to the organizational form of the affiliate (branch or subsidiary). Furthermore, this study tests whether German banks adopted a type of pecking order similar to that of US banks. This puts the needs of the parent bank first and redirects funds internally in order to protect the most important parts of the banking organization in terms of its lending business (CETORELLI AND GOLDBERG (2012)). However, the literature has, so far, not compared branches and subsidiaries with regard to their role in internal capital markets. This paper aims to contributing to an understanding of global banks' fund management as well as to assess the role of securitized banking in the international transmission of a funding crisis.

Two strands of literature are linked in this study. These assess at different levels how the crisis was transmitted from subprime housing assets to bank refinancing and, ultimately, affected banks' lending activities. One strand of literature investigates how the financial crisis spread on refinancing markets from subprime-related assets to non-subprime related asset classes. KRISHNAMURTHY (2010) argues that the financial crisis has been a crisis especially in debt markets, as participants on these markets were no longer able to raise funds easily and quickly owing to the separation of fundamental values and market prices for certain assets. As a major source of funding shuts down, banks that do not have ready alternatives may downsize their lending activity either domestically or abroad, eventually reducing the financing of the real economy.<sup>1</sup> GORTON AND METRICK (2012) find strong correlation of counterparty risk measures with the spreads for many non-subprime-related asset classes that were used as collateral in refinancing transactions. They draw the conclusion that concerns about counterparty solvency and uncertainty about the value of the offered collateral led to a run on repo markets by investors, which is analogous to a run on banks by bank depositors. Since repo markets represented an major source of funding for financial institutions, the authors argue that this run on repo was the key accelerator of the crisis.<sup>2</sup> Such evidence calls for a closer investigation of repo funding as a major short-term funding source of multinational banks.

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1 MISHKIN (2011) alludes to the possibility that increasing uncertainty in a financial crisis also increases asymmetric information and thus reduces the bank's ability to distribute credit effectively to firms and households. DE HAAS AND VAN HOREN (2012A) lend empirical support to this suggestion by showing that foreign lending remained more stable when banks had close relationships with borrowers.

2 KRISHNAMURTHY ET AL. (2012) observe that US money market funds and security lenders, which were largely financing the shadow banking system via repos, ran from their investments and thus significantly contributed to deteriorating lending conditions on repo markets.

HÖRDAHL AND KING (2008) compare developments on the US repo market with refinancing conditions on the European repo market after the outbreak of the subprime crisis. They find that the size of the European repo market declined due to growing risk aversion, greater preference for cash, and the increasing volatility of prices. The findings by MARTIN ET AL. (2012) derived from a dynamic equilibrium model are consistent with this picture. They illustrate how short-term collateralized borrowing may become highly unstable in times of crisis. This environment was responsible for the fact that even large and well-established market participants were hit by the disruptions and were prompted to downsize their activities related to repo markets. European banks' access to this important source of funding consequently became limited. The present paper links this aspect to the ability of parent banks to provide funds to their foreign affiliates.

A second strand of literature suggests that the global nature of many large banks is key to the international transmission of funding shocks (see CETORELLI AND GOLDBERG (2011) for the transmission of dollar-funding shocks to emerging markets, PEEK AND ROSENGREN (1997) and (2000) on the decline in the lending of Japanese bank branches in the US upon funding shocks to their parent banks, as well as AIYAR (2011) and ROSE AND WIELADEK (2011) for the recent comparably large decline in lending by foreign-owned banks' affiliates in the UK). CETORELLI AND GOLDBERG (2012) show that US global banks reduced their net lending via the internal capital market to affiliates located abroad, the more they were exposed to the collapse of the asset-backed commercial paper market. DE HAAS AND VAN LELYVELD (2006) and (2010) as well as POPOV AND UDELL (2012) document that financially strong European parent banks can stabilize their central and eastern European entities' loan supply in a local crisis, but that they are not a source of strength for their subsidiaries in a global, systemic crisis like the recent one which has negatively affected their own balance sheets.<sup>3</sup> The crisis hit the lending business of banks harder if ex ante they had relied more on short-term funding via interbank markets and less on deposit funding (see CORNETT ET AL. (2010) and IVASHINA AND SCHARFSTEIN (2010) for US banks, and DÜWEL AND FREY (2012) for German banks). The present study provides evidence for the transmission of a repo funding shock via internal capital markets of multinational banks.

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3 Further studies reveal that cross-border lending, either in the form of syndicated lending (IVASHINA AND SCHARFSTEIN (2010), GIANNETTI AND LAEVEN (2012) or DE HAAS AND VAN HOREN (2012B)) or direct cross-border lending (SCHNABL (2012)), suffered from crisis-related funding shocks.

This paper shows that German parent banks which were more exposed to the run on repo markets during the financial crisis were more aggressive in reducing their liquidity provision to foreign affiliates, especially after the subprime market collapse and the Bear Stearns rescue. Hence, funding via repo markets is found to be one channel that transmitted shocks primarily related to the US financial system abroad. The strongest negative impact on intra-bank lending induced by the repo funding shock can be observed after the Bear Stearns rescue, the event which raised even greater concerns about the solvency of potential counterparties in the interbank lending market. The further decline of the repo market after the Lehman Brothers bankruptcy triggered lower adjustments on internal capital markets, possibly because rescue measures conducted by central banks provided alternative funding sources. All in all, the distortions related to funding via repo markets contributed to the continuity and the development of the funding crisis.

The results reveal significant differences between branches and subsidiaries regarding fund management with these two types of affiliates. German banks restricted their support to foreign subsidiaries which were strong in raising funds locally, and redirected these funds to the parent bank. Conversely, branches located abroad were given greater protection, the more important was their individual lending business compared to the rest of the bank holding company. This finding reflects the larger role of branches in financing foreign real economies compared with that of subsidiaries.

However, this clear pattern in fund management can be observed only at the beginning of the crisis. With increasing disruptions on short-term funding markets and repo markets in particular, the scope of German parent banks to protect branches with an important lending business narrowed. However, better capitalized parent banks were able to shelter their foreign affiliates from the withdrawal of funds after the Bear Stearns rescue. This result supports the view that a stronger equity capital base can effectively signal stability to the market in times of distress.

The remainder of the paper is organized as follows: Section 2 discusses the disruptions that occurred on European repo markets during the financial crisis and the reliance of German banks on repo financing. Section 3 describes German banks' movements on internal capital markets in the crisis. Section 4 outlines the analysis and presents the methodology. Section 5 presents and discusses regression results, section 6 provides robustness tests. Section 7 concludes.

## 2 Repo funding of German multinational banks

### 2.1 Key developments on the European repo market in the financial crisis

The declining participation of banks in repo market financing was a central characteristic of the evolving financial crisis in Europe. In their June and December 2008 surveys among European financial institutions, the International Capital Market Association states that, for the first time since the beginning of the biannual survey in 2001, there were more banks with contracting than with expanding repo books. The market also saw a drastic shortening of maturities and a total contraction of the volume of repo transactions by 26%, which was the largest fall recorded since the survey began.

Repurchase agreements are mostly short-term interbank loans (overnight or with a maturity of less than one month) that are secured or collateralized in most cases with some type of securities. A bank can lend cash on a short-term basis from another financial player, such as a bank or a money market fund, in exchange for securities, which the bank agrees to buy back at some time in the future. The lender provides, for example, €80 by imposing a haircut (eg 20%) on the security (having a market value of €100) and demands a repo rate (eg 10%) from the borrower, who then has to pay back €88. This way of obtaining (from the perspective of the borrower) short-term cash or a specific type of security (from the perspective of the lender) was believed to be fairly safe before the financial crisis.

However, with the crisis unfolding, uncertainty arose about the value of the collateral provided in these transactions. Besides, there was growing uncertainty about the liquidity of markets on which collateral such as asset-backed securities could be sold in the event that the counterparty defaulted on the repo loan. In general, counterparty risk rose. The spread of the Euribor to OIS, being an indicator of counterparty risk on interbank markets, rose considerably in mid-2007 when the subprime market collapsed.<sup>4</sup> It increased again after the Bear Stearns rescue in March 2008 and peaked with the collapse of Lehman Brothers in September 2008 (see AIYAR (2011)). These developments led to increasing haircuts and repo rates. For some asset classes used as collateral, the repo market shut down completely (GORTON AND METRICK (2012)).

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<sup>4</sup> The conditions attached to an overnight index swap (OIS) result in minimum credit risk associated with this type of interest rate swaps. The spread against the Libor or Euribor therefore measures credit risk in the interbank market.

Recent literature has highlighted the role of the events that occurred in July/August 2007, March 2008 and September 2008 in the development of the financial crisis. KACPERCZYK AND SCHNABL (2010) see the failure of two Bear Stearns hedge funds in July 2007 as the first signal of the subprime market collapsing and as the starting point of the crisis in debt markets. In the same month, the German bank IKB became the first European victim of the crisis. Both institutions had heavily invested in the US subprime mortgage market. On August 7 2007, BNP Paribas was unable to assess the value of subprime-related assets held in some of its money market funds and suspended the redemption of shares. MISHKIN (2011) interprets this event as the key signal for deteriorating conditions on credit markets. What followed after July/August 2007 was a “fire sale” dynamic (SHLEIFER AND VISHNY (2011)), which led financial institutions to deleverage because of increasing uncertainty about the value of collateral offered in interbank refinancing transactions. The investment bank Bear Stearns collapsed in March 2008 due to its inability to secure funding on repo markets (BRUNNERMEIER (2009)) and was rescued with the support of the US regulators. This event focused attention on the run on debt markets and provoked another increase in counterparty and credit risk; MISHKIN (2011) points to the rise in the spread between interest rates on Baa corporate bonds and US Treasury bonds observed after the Bear Stearns event. Finally, the bankruptcy of Lehman Brothers on September 15, 2008 highlighted the deterioration in interbank lending conditions and the vulnerability of the global financial system.

Compared to the US market, the European repo market experienced lower distortions regarding the value of collateral used in repo transactions (HÖRDAHL AND KING (2008)). This was due to subprime-related asset classes being used to a lesser extent in Europe than in the US. Instead, there was a greater percentage of government securities used in repo transactions. Nevertheless, uncertainty about counterparty solvency and the liquidity of markets rose in Europe as well. Not only did lenders increasingly fear the default of repo loans, but borrowers were less willing to lend out their high-quality collateral, fearing that the securities would not return upon the default of the cash lender. It was common practice in both Europe and in the US for collateral to be “rehypothecated”, meaning that the collateral obtained in a repo agreement could be used by the lender in another repo transaction. This practice contributed to a multiplier effect when uncertainty about the value of collateral increased (see GORTON AND METRICK (2012)).

The dominance of bilateral repo agreements is another feature of the European repo market which might have played a part in growing mistrust among market participants. More than 50% of repo transactions in Europe are carried out on a bilateral basis (HÖRDAHL AND KING (2008)). This means that no central clearing party, which in a tri-party repo would keep the deposited collateral safe, stands between the borrower and the lender. Besides this, there was an increase in the number of “anonymous” settlements, in which the names of the borrower and the lender are known only to the central clearing counterparty, which testifies to the fact that many market participants feared that revealing their identity would worsen the lending conditions offered to them on repo markets (ICMA (JUNE 2008) and (DECEMBER 2008)).

## **2.2 Reliance on repo funding by German banks**

Monthly balance sheet data collected by the Deutsche Bundesbank from all banks registered in Germany provides the opportunity to study the individual exposure of each bank to the disruptions observed on repo markets during the financial crisis.<sup>5</sup> Next to a detailed reporting of the asset side of the balance sheet, banks provide, on a mandatory basis, information on the composition of their liabilities by counterparty sector and term structure. Besides this, the amount of funding achieved through repo transactions is reported. From this information, it is possible to assess the individual bank’s reliance on funding via repo markets, which determines their vulnerability to shocks on these markets.

As shown in Figure 1, before the outbreak of the subprime crisis, German parent banks funded, on aggregate, about one-third of their total claims (the total of accounts receivable) on the short-term wholesale market (short-term referring to an original maturity of less than one year), meaning via interbank loans including repo agreements with other monetary and financial institutions, own bonds and notes issued and repo agreements with non-banks, being, for example, central clearing counterparties.<sup>6</sup> This ratio of short-term funding to total claims remained stable until the bankruptcy of Lehman Brothers, when it decreased to less than 1:4. Repo funding as a share of German parent banks’ short-term wholesale funding on aggregate started to decline

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5 The bank-level data is confidential but can be accessed for research purposes on the premises of the Deutsche Bundesbank.

6 Up to June 2010, no information was collected regarding the maturity structure of repo funding. When the data became available, 96% of all repo agreements were short-term. In this study with a sample period that ends before 2010, it is therefore assumed that all repo funding is short-term funding.

as soon as the outbreak of the subprime crisis occurred. It dropped from a pre-crisis level of almost 60% of short-term wholesale funding to 48% just before the Bear Stearns rescue in March 2008 and accounted for no more than 35% of short-term funding after the Lehman Brothers bankruptcy (this is a total decline of almost 25 percentage points during this time span).

These figures point to the fact that repo funding as a short-term funding source became less accessible as soon as the outbreak of the crisis occurred, and had to be replaced with other short-term funding sources in order to limit the need to deleverage on the asset side of the balance sheet. The fact that the share of total claims financed by short-term funding in general (including repo funding) remained rather stable until the Lehman Brothers bankruptcy suggests that this replacement of repo funding was, on aggregate, possible at first. The immediate decline in repo funding compared with overall short-term wholesale funding might have been due to the fact that the subprime market collapse disproved the relative safety of repo transactions. The Lehman event severely worsened interbank lending conditions again. Alternative short-term funding sources (apart from repo funding) then started to dry up on an even broader scale, which led to a decline in the percentage of overall short-term funding in banks' total funding.

### **3 Internal capital markets of German banks**

#### **3.1 Movements observed during the financial crisis**

Along with increasing difficulties in accessing short-term funding via repo transactions, the effectiveness of the banks' internal fund management gained relevance. In order to fill funding gaps, the parent bank of a multinational banking organization can limit or redirect the funds that flow to affiliated banks abroad via the bank-internal capital market. In June 2007, 60 banks in Germany had affiliates located in foreign markets (see Table 1, domestically owned and foreign owned). In total, the German banking sector had 310 foreign affiliates at that time; 32 of which belonged to banks in Germany that have a foreign majority shareholder. While these banks file regulatory reports in the same way as German parent banks do, they are not the headquarters of the respective multinational banks and might not have the same scope of action as a German parent bank. The analysis carried out below therefore concentrates on German parent banks.<sup>7</sup>

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<sup>7</sup> A robustness check including foreign owned banks located in Germany is provided in section 6.

During the core stages of the financial crisis (i.e. from mid-2007 until the end of 2009), the German parent banks' net amount of accounts receivable from their own foreign branches fluctuated between roughly €200 billion and €330 billion (see Figure 2, this is, from the point of view of the branches, equivalent to their net borrowing from the parent bank). This corresponds to a fluctuation in net funds provided to the branches of between 10% and 18% of their aggregate total assets. Subsidiaries were, on aggregate, providing net funds to the parent banks before the financial crisis. By the time of the Lehman collapse, their aggregate net borrowing amounted to roughly €50 billion (or about 10% of subsidiaries' aggregate total assets). There is, however, substantial heterogeneity in these figures. While some branches or subsidiaries became net providers of funds to the parent organization during the crisis, others increased their dependence on the parent bank.

Both branches and subsidiaries of parent banks registered in Germany file monthly balance sheet reports with the Deutsche Bundesbank.<sup>8</sup> Within this report, subsidiaries provide information on the amount of assets and liabilities that they hold vis-à-vis the German parent bank. From this, the fluctuations in the net borrowing position of subsidiaries can be calculated. Branches do not report the position vis-à-vis the parent bank explicitly. Since June 2010, new series on the internal capital market have been reported, including the position of branches vis-à-vis the rest of their banking group. From a comparison of these series' dynamics with the dynamics of the net borrowing position of branches vis-à-vis the German banking sector (excluding the central bank), DÜWEL AND FREY (2012) concluded that this position was a fair approximation of the borrowing of branches from their parent bank. This approximation is used here in order to follow the fluctuations in the individual branch's net borrowing from its parent bank during the financial crisis.

### **3.2 Branches' and subsidiaries' role in internal capital markets**

There are major differences between a bank's branches and its subsidiaries and these differences are relevant to their role in the bank's internal fund management. Branches are part of the parent banks' balance sheet, while subsidiaries are separate legal entities and fulfill regulatory

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<sup>8</sup> Several branches of one parent bank, which are located in the same foreign country, submit a single joint report. Subsidiaries of German parents file reports whenever the German bank is the majority shareholder.

capital requirements in the country in which they are located. Conditionally, branches operate mostly as an extension of the parent bank, and subsidiaries resemble more stand-alone banks. This is also reflected in the funding structure of branches and subsidiaries. Relative to their size, subsidiaries fund themselves, on average, to a larger extent locally than branches (see Table 1, *core funding role* of branches and subsidiaries). They are also less dependent than branches on funding received from the parent bank.<sup>9</sup> Before the crisis, subsidiaries funded, on average, 17% of their total assets on the internal capital market, while branches' net borrowing from the parent bank amounted, on average, to roughly 40% of their total assets.

Branches and subsidiaries of German banks are, on aggregate, quite important in supplying loans to the real sector of foreign countries: about two-thirds of German banks' real sector loans to foreign firms are channeled abroad via branches or subsidiaries (see DÜWEL, FREY AND LIPPONER (2011)). Of these, branches account for the vast majority of the loans, but, on average, are also larger than subsidiaries in terms of asset size (see again Table 1). As of June 2007, a German domestically owned multinational bank (below "German parent bank") served an average of 5.6 foreign countries via affiliated banks abroad. The list of countries and the number of parent banks that had set up affiliates in these countries can be seen in Table 3. The roles of specific branches and subsidiaries in the lending business of the bank holding company, as well as their ability to fund themselves locally suggests that, in times of distress, the fund management of the bank via the internal capital market takes these characteristics into account.

## 4 Empirical model

### 4.1 Outline of the analysis

**Investigation 1:** The first objective is to test whether the exposure of German parent banks to the distortions on repo markets during the financial crisis activated the banks' internal fund management, leading parent banks to withdraw and/or redirect liquidity within the bank holding company. One key aspect is to investigate whether the fund management was different depending on whether a foreign affiliate was a branch or a subsidiary.

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<sup>9</sup> Compared to other European or US multinational banks, German banks tend to borrow more at home and lend abroad, hence they fund fewer of their foreign assets in the respective local market (McCAULEY ET AL. (2010)).

The run on repo funding markets (as described, for example, by GORTON AND METRICK (2012)) was triggered by increasing concern about the value of collateral used in repo transactions and growing mistrust among market participants. In this analysis, three key events which raised these types of risk are considered with regard to their effect on the internal fund management of German global banks: the outbreak of the subprime crisis in July 2007, the rescue of Bear Stearns in March 2008, and the bankruptcy of Lehman Brothers in September 2008. Figure 1 shows the aggregate decline of repo funding as a short-term funding source of German banks around these events. For all three events, the amount of the foreign affiliates' net borrowing from their respective parent banks before the specific event is compared with the amount of their net borrowing after the event. If the exposure of parent banks to the disruptions on repo markets did indeed lead to a shortage of short-term funding sources on the part of the parent bank, we should then observe a limitation of the amount of funds provided to foreign affiliates, and hence a reduction in the affiliates' net borrowing from the parent bank.

**Investigation 2:** Second, it is investigated whether in times of distress the fund management within German global banks follows a similar type of locational pecking order as is the case within US banks (CETORELLI AND GOLDBERG (2012)). This would mean that the parent bank, while limiting the amount of funds provided to its foreign affiliates, adopts a strategy that distinguishes between "core investment locations" and "core funding locations". The larger the share of an affiliate is in the total volume of foreign lending to firms by the whole bank holding company, the more this affiliate fulfills the role of a "core investment" location. These affiliates would then be more sheltered from the withdrawal of funds due to their important role in banks' lending business to the real sector. Conversely, if parent banks, following a funding shock, withdraw even more funds from affiliates which are strong in local refinancing (relative to their total refinancing), then these affiliates fulfill the role of "core funding locations".

This part of the analysis furthermore addresses the ultimately empirical question of whether the organizational form (branch or subsidiary) influences the assignment of these roles to the affiliates. On the one hand, as subsidiaries are less dependent on the parent bank and resemble more stand-alone banks (see section 3.2), they should be predestined to be assigned the core funding role. Often, subsidiaries are former stand-alone banks which were acquired by the global bank and possess a large network of depositors and investors. On the other hand, subsidiaries have to

fulfill local regulatory requirements, which limits the possibility of withdrawing funds. Branches distribute, overall, more loans to foreign firms than subsidiaries, which suggests that they might rather be sheltered from the withdrawal of funds and be more protected due to their fulfilling a core investment role. However, branches are consolidated into the parent bank's balance sheet, which facilitates the withdrawal of funds from these entities, as no strict local regulatory requirements apply.

The three different events considered also allow to investigate whether the assignment of core investment and core funding roles was consistent throughout the different episodes of the financial crisis. With banks facing increasing stress on interbank markets, the ability to protect core investment locations, for example, might have faded in the course of the crisis.

**Investigation 3:** Third, it is argued above that increasing uncertainty about the value of collateral and counterparty solvency on repo markets were key in disrupting the short-term funding possibilities of parent banks during the financial crisis. It should then be the case that parent banks that were able to signal a high level of solvency (were better capitalized) and/or possessed greater liquidity were less forced to withdraw funds from their foreign affiliates despite their exposure to the run on repo markets. Informational advantages and implicit government guarantees of banks with a large balance sheet size could have facilitated access to short-term refinancing on capital markets. These aspects are tested here.

**Investigation 4:** Finally, the regression results can reveal whether, in terms of volume, one of the three events put particular pressure on parent banks to limit the allocation of funds to their foreign affiliates. For each event, the degree to which funds were withdrawn from branches and subsidiaries due to the run-on-repo exposure of the parent bank are quantified. The responses of banks with high and low exposures to the disruptions are compared with regard to the volumes of funds which the model predicts they will withdraw due to their shock exposure. This determines in which of the events a relatively large exposure of the parent bank to the run on repo markets put the most pressure on the net borrowing of branches and subsidiaries from the parent bank, leaving aside the special treatment of core investment or core funding locations. Although borrowing conditions on repo markets steadily worsened throughout the crisis (see description in section 2.1), banks might have sought other funding sources after the first shock

in order to limit their vulnerability to a further deterioration in borrowing conditions. Moreover, banks might have benefited from rescue measures conducted by central banks. Possibly, this response reduced the need to withdraw funds from foreign affiliates as the crisis progressed.

## 4.2 Methodology and variables

The empirical approach is based on the methodology established by CETORELLI AND GOLDBERG (2012). For each of the three events, a “pre” and a “post” period is defined. The difference between average net borrowing of foreign branches or subsidiaries after and before the event reveals whether the net amount of funds received by a particular branch or subsidiary from the parent bank subsequently increased or decreased. The time span of the pre and post periods of each event are marked in the time line of Figure 3.

For the three events, the dependent variable of the analysis is hence a first-difference variable defined in the following way, with  $NetBorrow_j$  corresponding to net liabilities of branch or subsidiary  $j$  vis-à-vis their parent bank:

Subprime market collapse (occurring in 2007m7):

$$\Delta NetBorrow_j = NetBorrow_j|_{avg(2007m7-2008m2)} - NetBorrow_j|_{avg(2007m1-2007m6)} \quad (1)$$

Bear Stearns rescue (occurring in 2008m3):

$$\Delta NetBorrow_j = NetBorrow_j|_{avg(2008m3-2008m8)} - NetBorrow_j|_{avg(2007m8-2008m2)} \quad (2)$$

Lehman Brothers bankruptcy (occurring in 2008m9):

$$\Delta NetBorrow_j = NetBorrow_j|_{avg(2008m9-2009m3)} - NetBorrow_j|_{avg(2008m4-2008m8)} \quad (3)$$

The period from 2007m1 to 2007m6 should accurately reflect the average level of net borrowing of a foreign affiliate before the first repo funding shock, which is the subprime market collapse. The results are nevertheless robust to extending (up to one year) or shortening (eg to four months) this time period. Moreover, the results remain unchanged if the collapse of the subprime market is fixed to August instead of July 2007. It is assumed that the level of the affiliate’s net borrowing from the parent bank after the funding shock manifests itself over the time period from 2007m7 to 200802. The pre and post periods of the second repo funding shock, the Bear Stearns rescue, are defined by the timing of the other two events, as it is assumed that no other comparable shock to repo markets occurs during this time period. The post period of the third

event, the Lehman Brothers bankruptcy, ends in 2009m3. This should exclude direct effects stemming from central bank measures, such as the covered bond purchase programme (starting in May 2009), which released the pressure from banks that depended strongly on securitized banking. The quality of the results remains unchanged if the month in which the respective event occurred is excluded from the post period.

Note that a reduction in the amount of a branch's or a subsidiary's net borrowing from the parent bank can occur on either the asset side or the liability side of the affiliate's balance sheet. Either the parent bank increases the amount of funds previously demanded from the foreign affiliate or it cuts the provision of funds to the foreign affiliate. It also has to be understood that a negative outcome of the dependent variable does not necessarily mean that a branch or a subsidiary becomes a net lender to the parent bank. It can also mean that the support previously given to the respective entity by the parent bank has been reduced, but that the branch or subsidiary still remains a net borrower from the parent bank.

The main explanatory variable is the exposure of parent banks to the distortions on repo markets just before the respective event (as defined below). Explanatory variables include further parent-bank specific variables (index  $i$ ) from before the respective shock event, variables specific to the foreign affiliate (index  $j$ ) before each event, and variables characterizing the host country of the foreign affiliate (index  $k$ ). The view on the data yields *three cross-sectional datasets*, one for each event. Eq. (4) is used to test all *three events separately* with regard to their effect on the internal fund management of the bank.

$$\begin{aligned} \Delta NetBorrow_j = & \alpha_0 * repo\_exposure_i + \alpha_1 * d\_sub * repo\_exposure_i & (4) \\ & + \beta_0 * X_j + \beta_1 * d\_sub * X_j + \gamma * X_i \\ & + \eta_0 * X_k + \eta_1 * d\_sub * X_k + \kappa * Z_k + \varepsilon_j \end{aligned}$$

where

$$\alpha_0 = A_0 + B_0 * X_j + \Gamma * X_i + H_0 * X_k + K * Z_k \quad (5)$$

$$\alpha_1 = A_1 + B_1 * X_j + \Gamma * X_i + H_1 * X_k + K * Z_k \quad (6)$$

In order to determine whether the exposure of parent banks to the run on repo had effects on the net borrowing of subsidiaries that were different than those on net borrowing by branches from the parent bank,  $repo\_exposure_i$  in Eq. (4) is interacted with a dummy variable, which

equals one if the affiliate  $j$  is a subsidiary ( $d_{sub}$ ). Affiliate-specific characteristics and some characteristics of the host country, which are expected to play different roles for branches and subsidiaries, are also interacted with this dummy variable.

With Eq. (5) and (6) plugged into Eq. (4), the regression equation suggests that the severance with which the exposure of the parent bank  $i$  to the distortions on repo markets ( $repo\_exposure_i$ ) affects changes in the net borrowing position of branches and subsidiaries ( $\Delta NetBorrow_j$ ) depends on further characteristics of the parent bank ( $\Gamma * X_i$ ) as well as characteristics of the foreign branch  $j$  ( $B_0 * X_j$ ) or subsidiary  $j$  ( $B_1 * X_j$ ) and the country  $k$  ( $H_0 * X_k$  or  $H_1 * X_k$ ,  $K * Z_k$ ) in which the affiliate is located.

- The  $repo\_exposure$  of the parent bank is defined as the reliance on repo funding relative to short-term wholesale funding of the parent bank, in amounts outstanding *at the end of the month prior to the event*.<sup>10</sup>
- $X_j$  are affiliate- (branch- or subsidiary-) specific characteristics, namely the total *size* of the affiliate's balance sheet, the degree to which the affiliate fulfills a *core investment role* (share of the affiliate in the bank holding company's total lending to the foreign non-bank private sector, measured in loan stocks outstanding) and the intensity with which the affiliate takes the *core funding role* (the affiliate's local liabilities relative to its total liabilities). All of these characteristics are calculated as *averages over the pre period of the respective event*.<sup>11</sup>
- $X_i$  is a vector of further parent bank characteristics. It includes the total *size* of the parent bank's balance sheet, parent bank *capitalization* (equity capital / total assets) and parent bank *liquidity* (liquid assets / total assets), all in *averages over the pre period of the respective event*.<sup>12</sup>

10 Repo funding and short-term wholesale funding of the parent bank exclude positions held vis-à-vis affiliated banks abroad. Short-term wholesale funding includes interbank liabilities (including repo agreements with other monetary and financial institutions), own bonds and notes issued and repo agreements with non-banks, such as central clearing counterparties. Short-term refers to an original maturity of less than one year.

11 The data for calculating these positions are taken from the monthly External Positions Report, which the banks submitting balance sheet positions fill out as well. It provides a breakdown of banks' lending and funding abroad by the different foreign countries (FIORENTINO, KOCH AND RUDEK (2010)).

12 Parent banks' liquid assets are defined as the sum of cash holdings, claims on the central bank, short-term claims on other (unaffiliated) banks and holdings of short-term securities. Possibly, liquidity is slightly smaller than in this calculation, because some liquid securities are held on the balance sheet but are in fact lent out, for example, in a repo and are therefore not immediately available. This should, however, not be the majority of the positions. The correlation between liquidity and repo exposure is negative and small (-11%), which supports this view.

- $X_k$  are dummy variables characterizing the host country of the affiliate:  $d_{fin\_platform}$  marks countries which represent financial platforms to German banks. Affiliates which are located in these countries might have been hit more by the original events, since they were heavily involved in the trading of securities on international financial markets. Financial platforms are financial centers, mainly offshore (the list is taken from the Financial Stability Forum (2000)), as well as the UK and the US. These countries are marked with an asterisk in the list of host countries of German banks' foreign affiliates (Table 3). Another dummy is introduced for the euro area, inside which affiliates are geographically close to the parent bank and operate mainly in the same currency ( $d_{euro\_area\_no\_fin\_platform}$ ). Only countries that do not represent major financial platforms are included here in order to avoid overlapping with the other dummy variable in this category.<sup>13</sup>
- $Z_k$  contains a continuous financial openness indicator (CHINN AND ITO (2008)) for each country ( $fin\_openness$ ).<sup>14</sup> As this indicator is not specific to the mode of operation in these countries (via branches or subsidiaries), its impact is not estimated separately for the two types of affiliates.

See Tables 1 and 2 for descriptive statistics on the different variables.

### 4.3 Interpreting the estimated coefficients

If it is true that the exposure of parent banks to the run on repo exerted significant pressure on the net borrowing of branches from the parent bank, then  $A_0 < 0$  (see Eq. 5). If the same applies to subsidiaries, then  $A_0 + A_1 < 0$  (see Eq. 5 and 6).  $A_1$  gives the difference between branches and subsidiaries regarding the change in net borrowing from the parent due to the parent bank's run-on-repo exposure. **(Investigation 1)**

If other affiliate-specific characteristics, such as a core investment or core funding role of a branch or subsidiary, influenced the degree to which the parent bank's exposure to the disruptions on repo markets affected net borrowing of this branch or subsidiary, then the corresponding

<sup>13</sup> The quality of the results remains unchanged if, in addition, a dummy variable for emerging markets in Asia or a dummy variable for eastern European countries is included. Both regions may have been sheltered more from the withdrawal of funds since they were fairly untouched by the initial shocks and, therefore, represented important investment markets. However, the dummies turn out insignificant in the regressions.

<sup>14</sup> The index is calculated from information given in the Annual Reports on Exchange Arrangements and Export Restrictions (AREAER) prepared by the International Monetary Fund. It is a de jure financial openness indicator.

coefficients estimated within the vector of coefficients  $B_0$  (for branches) or  $B_0 + B_1$  (for subsidiaries) should be significant. A positive sign then means that this particular characteristic (eg the *core investment role* of an affiliate) buffers the negative impact on net borrowing stemming from the parent bank's exposure to the run on repo. A negative sign means that this characteristic (eg the *core funding role*) amplifies the withdrawal of funds from this affiliate in response to the parent bank's shock exposure (see Eq. 5 and 6 as plugged into Eq. 4). **(Investigation 2)**

In a similar fashion, it is analyzed whether the parent bank having a higher level of capitalization buffers the impact of the exposure to the run on repo on the internal borrowing of the affiliate. If the specific coefficient of the vector  $\Gamma$  was estimated to be positive, this would be the case. **(Investigation 3)**

## 5 Results

Table 4 depicts regression results for the event of the subprime market collapse, Table 5 addresses the Bear Stearns rescue, and Table 6 reports results for the analysis of the Lehman Brothers bankruptcy. Whenever a variable has been interacted with the subsidiary dummy, the total effect of this variable on a subsidiary (not just the deviation from the effect estimated for a branch) is reported in the second numerical column of each table. In each regression, the explanatory variables are jointly significant. Standard errors are clustered by parent bank. The regression results reported concentrate on the sample of German parent banks and hence exclude foreign-owned banks, which are likely to fulfill other tasks and have a smaller scope of action than a parent bank headquartered in Germany. Nevertheless, a robustness check in section 6 includes foreign-owned banks in the regressions.

### 5.1 Investigation 1: Transmission of the funding crisis occurs via repo funding and via bank-internal capital markets

In all three events, it can be shown that the exposure of the parent bank to the distortions on repo markets (*repo\_exposure*) negatively affected the provision of funds to foreign affiliates (hence the net borrowing of affiliates from the parent bank,  $\Delta NetBorrow$ ).

After the subprime market collapse (Table 4), the negative impact of the shock hitting short-term funding possibilities of the parent bank was the same for both branches and subsidiaries. This can be concluded from the observation that the exposure of the parent to the run on repo (*repo\_exposure*) is significantly negative for both types of affiliates, and that the two effects are not statistically different from each other. After the Bear Stearns rescue (Table 5), the parent bank's exposure to disruptions on repo markets had a significantly larger impact on the withdrawal of funds from branches than from subsidiaries. The impact of *repo\_exposure* on the net borrowing of both types of affiliates is significantly negative ( $A_0$  and  $A_0 + A_1$  are both significantly negative, see Table 5), and the effect on subsidiaries deviates positively (and significantly) from that on branches ( $A_1$  reported in the last column). Finally, after the Lehman Brothers bankruptcy (Table 6), the repo market exposure of parent banks exerted a negative pressure on the net borrowing of branches from the parent bank, but not on that of subsidiaries. Hence, while the parent bank's exposure to the run on repo had an equally strong impact on branches' and subsidiaries' net borrowing after the subprime market collapse, it had a significantly stronger impact on branches after the two subsequent events. In the course of the crisis, the degree to which funds could be withdrawn from subsidiaries might have declined faster than from branches because subsidiaries had to continue fulfilling regulatory capital requirements, while branches are consolidated into the balance sheet of the parent bank for regulatory purposes. Especially in the short run, this aspect might have influenced the parent banks' fund management decisions. Furthermore, branches had received more support from the parent bank to begin with, and hence the scope to withdraw funds might have been larger.

In general, after all three events, the internal fund management of the multinational banks reflects the increasing difficulty experienced by parent banks in rolling over their short-term debt on repo markets. Their funding difficulties affect, via internal capital markets, the financing of their foreign affiliates. This finding supports the idea of the parent bank as the central decision-making entity of the global bank and reinforces the notion of an organizational pecking order, which puts the needs of the parent bank first (as described by CETORELLI AND GOLDBERG (2012) for US banks). Furthermore, the significant impact of the run on repo on bank-internal fund management provides evidence for the transmission of the funding crisis both through repo financing on capital markets and through bank-internal capital markets.

## 5.2 Investigation 2: Fund management pattern dependent on type of affiliate and crisis episode

According to the results, the fund management of German global banks in the financial crisis initially followed a pattern of assigning to certain affiliates a *core investment role* or a *core funding role* (as defined in section 4.2). With the parent bank's increasing exposure to the disruptions on repo markets, branches with important lending business compared with the rest of the bank holding company were, at the time of the subprime market collapse, sheltered more from the withdrawal of funds by the parent bank. (see regression results: *repo\_exposure\*core investment role* in Table 4, column "total effect branches"). Subsidiaries which had a greater ability to raise funds locally fulfilled a *core funding role* after the subprime market collapse as well as after the Bear Stearns rescue, the more the parent bank was exposed to the run on repo (see coefficients for *repo\_exposure\*core funding role* in Table 4 and Table 5, column "total effect subsidiaries"). No effect of either the core investment role or the core funding role can be detected in fund management following the Lehman Brothers bankruptcy (Table 6).

The results suggest that it was only at the beginning of the financial crisis that parent banks assigned the *core investment role* to certain branches, and only branches. The buffering effect of this role vanishes, however, with the rescue of Bear Stearns. Possibly, this next unexpected shock to repo funding amplified the parent banks' needs to limit the provision of funds to foreign affiliates, resulting in a smaller scope for the stabilization of branches that were important for lending business abroad. After both the collapse of the subprime market and the rescue of Bear Stearns, subsidiaries, and only subsidiaries, fulfilled the *core funding role* the more they refinanced themselves locally. This may be due to the fact that subsidiaries are more likely to have a strong standing in the local funding market. When subsidiaries are former stand-alone banks, which at one point became part of the global bank holding company, they possess a larger network of depositors and investors than branches, which are often established from scratch. Branches, on the other hand, have a greater responsibility within the bank holding company for the provision of loans to the real sector abroad. Moreover, they are more dependent overall on funding provided by the parent bank (see section 3). These aspects might explain the differences detected in fund management with regard to branches and subsidiaries.

The pattern followed by the parent banks' fund management became less clear the longer the crisis lasted. After the Bear Stearns rescue had taken place, parent banks became less engaged in protecting core investment locations than they had been after the subprime market collapse. After the Lehman Brothers bankruptcy, fund management no longer makes any distinction between core investment and core funding locations, either for branches or for subsidiaries. Possibly, the Bear Stearns rescue fomented mistrust in the stability of large global banks, which worsened their funding conditions. There was subsequently a decline in the parent banks' scope for sheltering affiliates with a more important lending business.

### **5.3 Investigation 3: Higher parent bank capitalization signals stability after Bear Stearns rescue**

Even if a parent bank's exposure to the run on repo is large, the bank can avoid losing its counterparty's trust if it shows credibly that it is solvent and can withstand shocks to its funding sources. A bank with a larger share of equity capital in total assets can signal stability to the market in times of distress (KICK AND KOETTER (2007)). Higher liquidity may help overcome temporary disruptions to funding sources. Larger banks are more likely to be implicitly guaranteed by the government (since they are "too big to fail"), which may reduce their probability to default and thus facilitates the raising of funds from investors. The results show that, after the Bear Stearns rescue, banks with a higher level of capitalization were better able to buffer the negative impact on intra-bank borrowing of foreign affiliates, which resulted from their exposure to the run on repo (see estimated coefficient for  $repo\_exposure * capitalization$  in Table 5). This is consistent with the picture that the troubles of Bear Stearns demonstrated for the first time in the financial crisis that even large banks were seriously vulnerable to the disruptions observed on financial markets. Therefore, it became more important for these banks to be soundly capitalized, which signaled high solvency to repo market investors.

### **5.4 Investigation 4: The repo funding shock's magnitude compared across events**

The negative impact of a high exposure to the disruptions on repo markets on foreign affiliates' net borrowing from their parent banks was not only significant, but also quite large in scale.

A closer investigation of the repo funding shock across the three different events furthermore suggests that banks did not react or were unable to react sufficiently to the first event so as to avoid being notably affected by future repo funding shocks.

The model, as estimated in sections 5.1 to 5.3, predicts that the Bear Stearns rescue was the event which forced parent banks with a relatively high run-on-repo exposure to conduct the largest reduction of funds provided to foreign affiliates compared with the other two events. In order to demonstrate this, for each event the stand-alone effect on net borrowing of affiliates stemming from the parent bank's high run-on-repo exposure is compared with the effect stemming from a low exposure of the parent bank. The results of this exercise are reported in Table 7. The average exposure of the parent bank to the disruptions on repo markets (hence the average share of repo funding in overall short-term wholesale funding) is calculated for the group of parent banks with a high exposure (above the 75th percentile of the distribution) and those with a low exposure (below the 25th percentile of the distribution) in each of the three events. Then, the average impact of a high and a low exposure on the net borrowing of branches and subsidiaries is calculated using the coefficients estimated for the three different events as reported in Tables 4 to 6. As the average parent bank below the 25th percentile of the distribution uses no repo funding, the impact calculated for an average bank with a high repo exposure signals, at the same time, the difference between a low and high exposure.

For both branches and subsidiaries, the average stand-alone effect of a high run-on-repo exposure on the volume of net internal borrowing from the parent bank is predicted to be the largest after the Bear Stearns rescue (-€2.3 billion or -127% of absolute pre event average net borrowing for branches, -€1.4 billion or -600% for subsidiaries). The second largest average withdrawal is predicted for the subprime market collapse (-€1.36 billion or -100% for branches, -€1.13 billion or -281% for subsidiaries). These figures might appear quite large, but it has to be kept in mind that they represent the stand-alone effect predicted for a bank with a very high exposure to disruptions on repo markets. The short-term wholesale funding of this type of bank depended to over 60% on repo financing. While a bank with a very high exposure to the disruptions is predicted to withdraw larger volumes of funds from branches than from subsidiaries, the relative impact appears stronger for subsidiaries, since they were borrowing fewer funds from the parent bank to begin with. After the Lehman Brothers bankruptcy, a bank with

a high exposure is predicted to having withdrawn €0.72 billion (or 39%) from branches. No significant stand-alone impact can be detected on the net borrowing of subsidiaries.

These figures suggest that the subprime market collapse had a strong impact on banks' internal fund management. However, after this first shock, parent banks did not or were unable to limit their exposure to future repo funding shocks. The even larger volume of funds that the model predicts to have been withdrawn after the Bear Stearns rescue suggests that this second shock severely increased the pressure on parent banks' short-term refinancing again. After this watershed event, parent banks restricted their need to transmit their short-term refinancing problems via internal capital markets to their foreign affiliates. The Lehman Brothers bankruptcy, even though it represented an intensifying shock to confidence on capital markets, was then less reflected in the movements of funds on internal capital markets.

It is likely that the actions taken by central banks to provide alternative funding possibilities had an impact as well. The European Central Bank started expanding the Eurosystem's collateral framework in October 2008 and lowered the minimum credit rating from A- to BBB- in order to counter the tensions on interbank markets. Furthermore, the launch of the covered bond purchase programme was announced for May 2009. Covered bonds were widely used as collateral for obtaining liquidity in the euro area (see FEGATELLI (2010)). These support measures might have eased the pressure on banks that were strongly dependent on securitized banking.<sup>15</sup>

## 6 Robustness of results

### Possible endogeneity of run-on-repo exposure in later events

The main econometric analysis assumes that the ex ante run-on-repo exposure of parent banks is exogenous to the ex post withdrawal of funds related, respectively, to the subprime market collapse, the Bear Stearns rescue and Lehman Brothers bankruptcy. Since the three events occurred successively, this assumption may be very strong. It is conceivable that the amount of funding provided to a parent bank's foreign affiliates after the subprime market collapse (on average

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<sup>15</sup> BUCH, KOCH AND KÖTTER (2011) show that parts of German bank holding companies also profited via intra-bank spillovers from the US Federal Reserve's Term Auction Facility, which was introduced in June 2008 in response to the Bear Stearns event.

during 2007m7-2008m2) is related to the amount of funding which a parent bank obtained via repo transactions directly before the Bear Stearns rescue (in 2008m2). This could be the case since a parent's bank's repo funding might be persistent between 2007m7 and 2008m2. Since the degree to which foreign affiliates were supported via the internal capital market before the Bear Stearns rescue enters the calculation of the change in net internal borrowing of affiliates in response to this event, the run-on-repo exposure of the parent bank might be endogenous to the analysis. Likewise, it is possible that the exposure of parent banks to the repo market distortions triggered by the Lehman Brothers bankruptcy is endogenous to the subsequent change in the provision of funds to foreign affiliates via internal capital markets.

Although the run-on-repo exposure of parent banks is calculated on a different observational level (the parent bank) than the change in net borrowing of affiliates (the affiliate level), an instrumental variables approach is conducted as a robustness test. The run-on-repo exposure of the parent bank at the time of the Bear Stearns rescue and the Lehman Brothers bankruptcy is instrumented with its value observed before the subprime market collapse, and hence before the first event which potentially affected the bank's repo funding behavior. Due to the time lag, this instrument can affect the dependent variable in later events only through its own future value, which is the main explanatory variable in the analysis.

It turns out that the run-on-repo exposure of parent banks from 2007m6 is a valid instrument for their run-on-repo exposure observed in 2008m2, and thus before the Bear Stearns rescue. This can be concluded from the first-stage regressions (not reported) of the two-stage-least-squares estimation as well as from the identification test (see Table 8). Conversely, neither the run-on-repo exposure of parent banks from before the subprime market collapse nor that from before the Bear Stearns rescue provide sufficient identification for the exposure of parent banks to the repo market distortions triggered by the Lehman Brothers bankruptcy (results not reported). This finding corroborates the previously stated finding that the exposure of parent banks to shocks on repo markets was quite persistent throughout the first two episodes of the crisis, but that it changed after the Bear Stearns rescue as banks adjusted their funding behavior. They responded to the deterioration of confidence in well-established market participants. As concluded from the main analysis, the Lehman Brothers bankruptcy thereafter had a significantly lower impact on the banks' internal fund management.

Where the instrumentation of the run-on-repo exposure with an earlier value is valid (in the event of the Bear Stearns rescue), the regression results are reported in Table 8. The quality of the results, as obtained from ordinary least squares regression (Table 5), are unchanged in the instrumental-variables approach. The robustness test thus reinforces the conclusions previously drawn.

### **The branches' and subsidiaries' own exposure to short-term funding problems**

Branches and subsidiaries also refinance themselves to some degree on short-term wholesale funding markets. Following a worldwide shock to these markets, this might have an effect on their ability to do without internal support from their parent bank. If, in the course of the financial crisis, branches and subsidiaries with a greater exposure to shocks to short-term funding markets were supported to a larger extent by their parent banks, this affiliate characteristic should then dampen the negative impact of a large run-on-repo exposure of the parent bank. It is indeed found to be the case that upon the repo funding shock experienced by the parent after the Bear Stearns rescue, subsidiaries with a larger share of short-term wholesale funding in total assets were more protected. Possibly, the obligation of subsidiaries to fulfill local regulatory capital requirements prompted the need to take the subsidiary's own short-term refinancing problems into account with regard to the amount of net borrowing that it was granted.

The main analysis assumes that the deteriorations on repo markets hit, first and foremost, the parent bank, which then controlled the fund management of the bank. The reliance of affiliates on repo funding as a specific short-term funding source was presumably very limited in comparison to the parent bank. Branches of German banks have conducted, on average, only 2%-3% of their short-term wholesale funding via repo markets during the crisis. Parent banks, in contrast, have relied to roughly 20% on this short-term funding source. It is therefore unlikely that the drying-up of repo markets had large effects on branches. For subsidiaries, no information on the share of repo funding in short-term wholesale funding is available. Possibly, it is larger than that of branches, since, in terms of their funding structure, subsidiaries resemble more stand-alone banks. This might be another reason for the observation that subsidiaries with a greater reliance on short-term wholesale funding were sheltered more from the withdrawal of funds.

## **Inclusion of foreign-owned banks in the analysis**

Foreign-owned banks were previously excluded from the analysis, as identification relies on the assumption that the parent bank is the decision-making entity with regard to the fund management of the bank. Since foreign-owned banks in Germany (which themselves have branches and/or subsidiaries) are not the headquarters of bank holding companies, they are very likely to differ in their operations from German parent banks. When they are included in the regressions, the quality of the main results (the significant impact of the run-on-repo exposure on the internal fund management) remains unchanged, except for the event of the subprime market collapse. Here, the repo exposure of the parent bank is irrelevant. In the other two events, the magnitude of the effects is slightly smaller. This can result from the fact that foreign-owned banks rely, on average, less on repo markets than German parent banks (9%-12% for foreign-owned banks versus 19%-24% for German parent banks, see Table 1).

Regarding the relevance of parent bank characteristics, the regressions which include foreign-owned banks assign more importance to parent bank liquidity. For foreign-owned banks, which are not the headquarters of the multinational bank, it might be more important to have liquid assets available to support own affiliates than to demonstrate solvency to other market participants. The regressions feature a dummy variable for foreign-owned banks. Upon the shock experienced due to the Lehman Brothers bankruptcy, foreign-owned banks withdraw significantly more funds from their foreign affiliates than domestically owned banks.

## **7 Conclusions**

This study uses confidential bank-level data on German parent banks and their foreign branches and subsidiaries to investigate fund management within the multinational bank upon a shock to the parent bank's refinancing possibilities in the course of the financial crisis. It is demonstrated that the exposure of German parent banks to the disruptions observed on the sale and repurchase markets (the repo markets) after the subprime market collapse, the Bear Stearns rescue and the Lehman Brothers bankruptcy significantly reduced bank-internal borrowing of funds by foreign branches and subsidiaries from the parent bank. Hence, the crisis-related shocks to short-term

funding are transmitted via both repo markets and bank-internal capital markets.

In terms of magnitude, the stand-alone effect of the parent banks' repo market exposure on the withdrawal of funds from foreign affiliates was strongest, for both branches and subsidiaries, after the Bear Stearns rescue. Although the collapse of the subprime market in July 2007 represented a dramatic shock to banks' short-term refinancing sources, this study finds that banks did not or were unable to reduce their exposure to these types of disruptions until after the Bear Stearns failure in March 2008. The bankruptcy of Lehman Brothers in September 2008 then triggered less reallocation of funds via bank holding companies' internal capital markets. Measures introduced by central banks after the Bear Stearns rescue might also have played a part in this.

Nevertheless, major differences between the two types of affiliates can be detected regarding the internal fund management of parent banks. Overall, the empirical analysis predicts fewer funds to be withdrawn from subsidiaries than from branches due to the parent bank's run-on-repo exposure. But these volumes imply a stronger relative effect on subsidiaries, since they borrowed on a net basis, on average, fewer funds from parent banks to begin with. Subsidiaries were more likely to be used as "core funding locations" in the early stages of the crisis, while branches were used more as "core investment locations"; in other words locations within the bank holding company which were relatively important in delivering credit to the foreign real sector. Both effects vanish in the course of the crisis, with the use of core funding locations continuing longer than the protection of core investment locations. This finding suggests that parent banks' increasing troubles in rolling-over short-term debt allowed a consistent protection of major lending markets to an ever decreasing extent, the longer the crisis on debt markets persisted. Better capitalized parent banks felt less impelled to withdraw funds from their foreign affiliates after the Bear Stearns rescue despite their exposure to the disruptions on repo markets. All in all, for globally active banks, short-term refinancing aspects at the level of the parent bank have implications for the whole bank holding company. The difference in the volumes of funds withdrawn from branches and from subsidiaries might be due not only to different funding structures, but also to their organizational forms (subsidiaries have to fulfill local regulatory requirements at all times). This might set incentives to augment the volume of liquidity withdrawal from branches in times of crisis, and might explain why some global banks have lately

transformed subsidiaries into branches.

It is true that the financial crisis disrupted unsecured funding markets in general, but this study shows that it also had severe effects on secured funding markets, such as repo markets. The results presented here furthermore suggest that disruptions to repo markets were already being reflected in the internal fund management of multinational banks at the time of the subprime market collapse. This type of funding was believed to be quite safe before the financial crisis, but many financial institutions ran from their investments in repo markets when uncertainty about the value of the collateral and the solvency of the counterparty unexpectedly increased.

Demand for high quality collateral, such as government bonds, rose dramatically in the course of the crisis. On the European repo market, it is common to use a bundle of government bonds from euro-area countries as collateral in repo transactions. Now that the financial crisis has triggered a sovereign debt crisis, it has to be asked whether this type of collateral is still of the high quality that it is believed to be. On aggregate, banks are again increasing the share of short-term funding carried out via repo transactions, and it has been demonstrated in this paper that large globally active banks may withdraw funds from their affiliated banks abroad upon disruptions to these markets. This may affect the efficient allocation of credit to the real economy. It has to be kept in mind that the next distortion to collateral value might be linked to the declining creditworthiness of governments.

Another development should be observed closely as well. Growing mistrust among market participants led to an increase in the percentage of repo transactions settled with central clearing counterparties (tri-party repo). Although this might help overcome the loss of confidence in repo markets to some extent, it is leading to large volumes of transactions being concentrated on only very few institutions. Operational practices within these institutions lead to them providing a large amount of credit to their borrowers during the day, and settling this position again with the cash provided by the repo lender at the end of the day (a procedure called “unwinding”). From their theoretical model, MARTIN ET AL. (2012) draw the conclusion that this creates a destabilizing effect on the market, and that, on that date, it played a part in the bankruptcy of Lehman Brothers. The management of liquidity and the administration of collateral deposited with these institutions should therefore be monitored closely.

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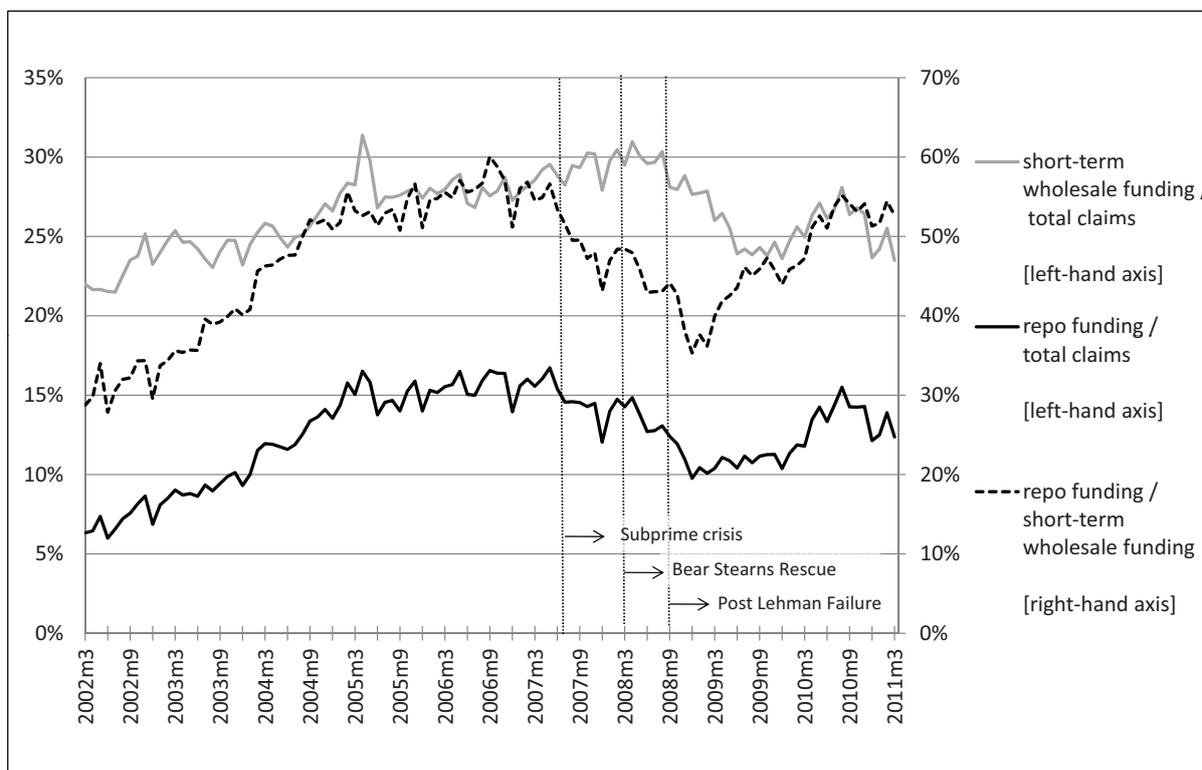
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# Appendix

## A Figures

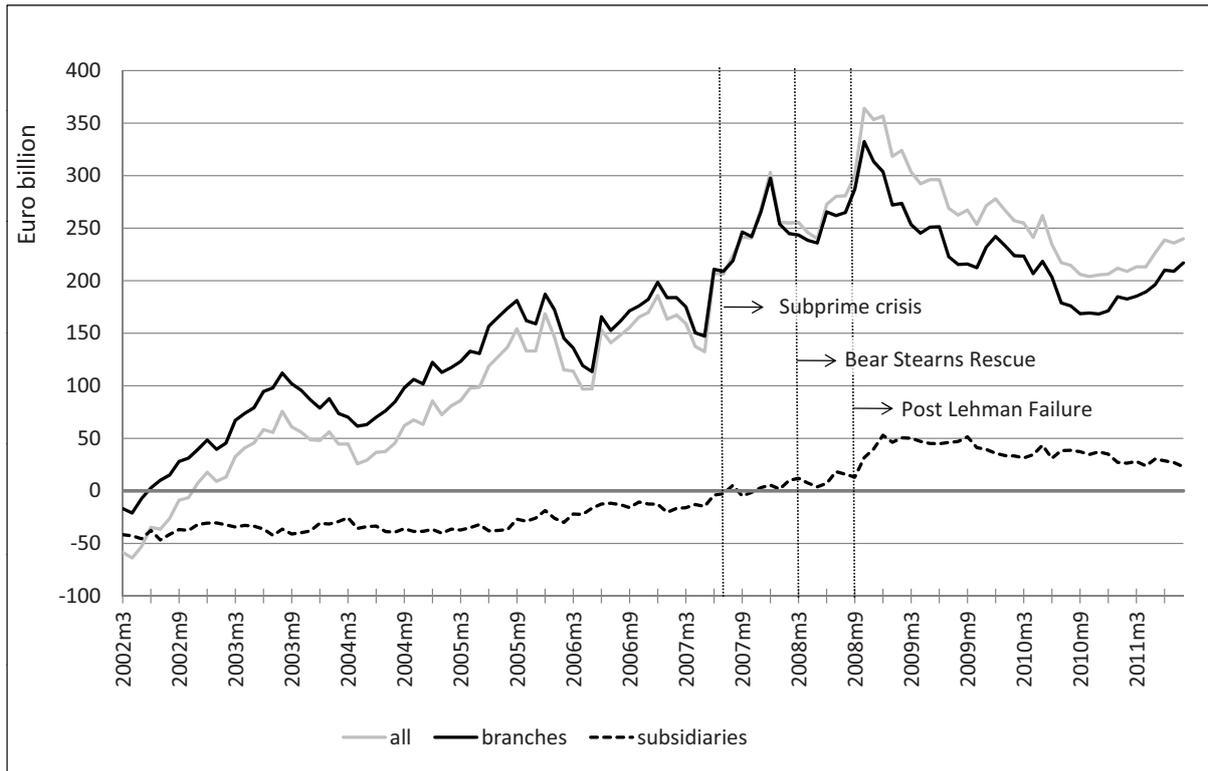
Figure 1: Aggregate short-term wholesale and repo funding of German parent banks



Source: Author's own calculations.

This graph illustrates the dynamics of short-term wholesale funding and repo funding of German parent banks. It is based on monthly reports of parent banks to the Deutsche Bundesbank. Repo funding and short-term wholesale funding of the parent bank exclude positions held vis-à-vis affiliated banks abroad. Short-term wholesale funding comprises funding via interbank loans (including repo agreements with other monetary and financial institutions), own bonds and notes issued and repo agreements with non-banks, being, for example, central clearing counterparties. Short-term refers to an original maturity of less than one year. Foreign-owned parent banks registered in Germany are not included; however, their influence on the aggregate is so small that their inclusion would not change the dynamics or the order of magnitude of the ratios.

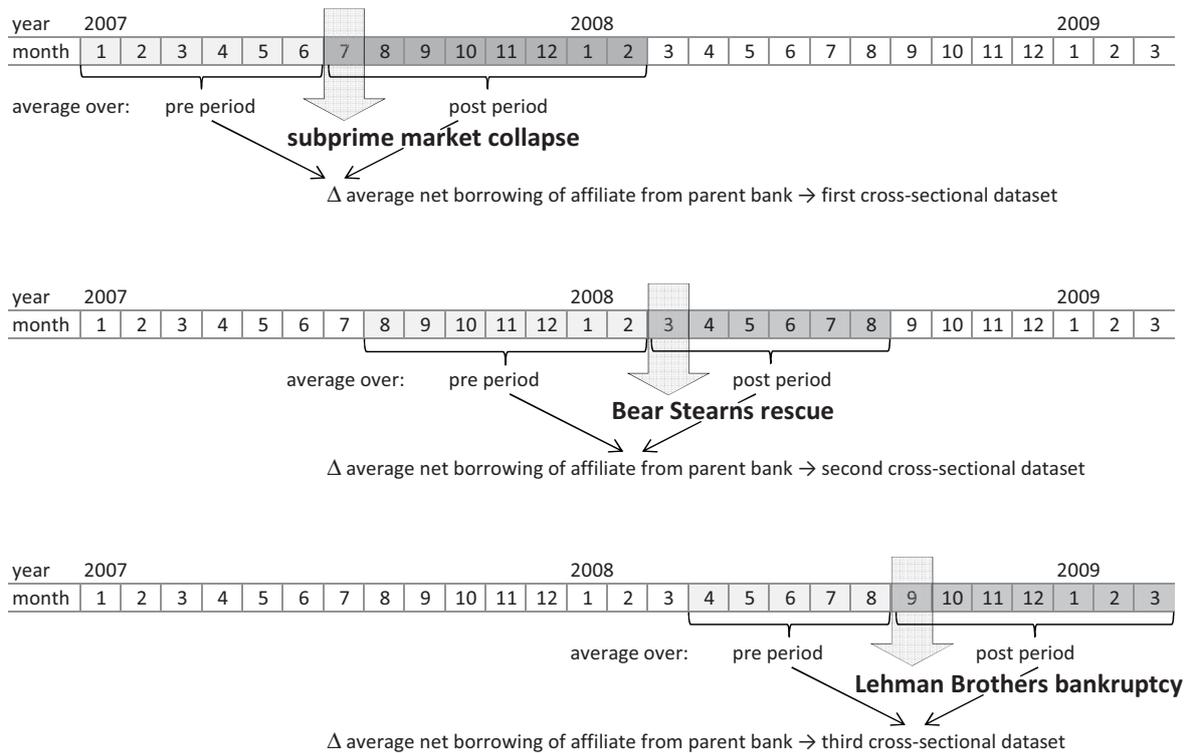
Figure 2: Aggregate net borrowing of branches and subsidiaries from German parent banks



Source: Author's own calculations.

The graph depicts aggregate numbers for net borrowing of branches and subsidiaries from German parent banks. The series are based on individual reports which each foreign affiliate of a bank headquartered in Germany reports on a monthly basis to the Deutsche Bundesbank. While subsidiaries report this position directly, it is approximated for branches to correspond with these entities' net borrowing from the German banking sector. For details, see section 4.2 and DÜWEL AND FREY (2012) who establish this measurement. Affiliates of foreign-owned banks registered in Germany are not included in the aggregate series. However, their volume of net borrowing is so small that it does not change the aggregate noticeably.

Figure 3: pre and post event periods of intra-bank lending during the financial crisis, yielding three cross-sectional datasets



This figure divides the time period of the financial crisis into pre and post periods for the three events considered in this study as amplifiers of uncertainty on repo markets (the subprime market collapse, the Bear Stearns rescue and the Lehman Brothers bankruptcy). Comparing the post event and pre event difference of a foreign affiliate’s average net borrowing reveals whether the level of net amount of funds received from the parent bank increased or decreased in response to the specific shock. This view of the data yields three cross-sectional datasets, one for each event. The quality of the regression results for all three events is robust to excluding from the post period the months in which the shocks occur. The results are also robust to shortening or extending the pre period of the subprime market collapse.

## B Tables

Table 1: Descriptive statistics on German parent banks and their foreign affiliates

Unless otherwise stated, all figures reported refer to domestically-owned banks, hence they exclude foreign-owned banks (banks with a foreign majority shareholder). The statistics are based on the regression samples. Maximums and minimums of bank-specific data are not shown here due to confidentiality.

Variable	Before Subprime market collapse		Before Bear Stearns rescue		Before Lehman Brothers bankruptcy	
	Mean	StD	Mean	StD	Mean	StD
<b>Parent bank level</b>						
	Avg: 2007m1-2007m6		Avg: 2007m8-2008m2		Avg: 2008m4-2008m8	
capitalization (equity capital / total assets)	0.042	0.018	0.041	0.019	0.047	0.028
liquidity (liquid assets <sup>a</sup> / total assets)	0.036	0.071	0.042	0.040	0.039	0.080
size (total assets) in € billion	85.412	103.884	89.128	108.405	81.989	111.291
	2007m6		2008m2		2008m8	
repo_exposure <sup>b</sup>	0.238	0.294	0.229	0.272	0.190	0.265
repo funding / total claims	0.083	0.137	0.086	0.136	0.086	0.187
short-term wholesale funding / total claims	0.223	0.199	0.240	0.215	0.266	0.252
(avg) # of countries served by branches and/or subsidiaries	5.6	8.0	5.7	8.3	5.6	8.1
# of parent banks, domestically-owned	42		42		48	
# of parent banks, foreign-owned	18		18		17	
<b>Affiliate level</b>						
<b>Branches</b>						
	Avg: 2007m1-2007m6		Avg: 2007m8-2008m2		Avg: 2008m4-2008m8	
net borrowing from parent bank / total assets	0.392	1.738	-0.006	1.768	0.168	1.387
core investment role <sup>c</sup>	0.069	0.134	0.066	0.126	0.067	0.119
core funding role <sup>d</sup>	0.242	0.258	0.222	0.249	0.231	0.261
size (total assets) in € billion	10.678	50.478	11.188	50.004	9.497	42.432
short-term wholesale funding / total assets	0.306	0.290	0.292	0.294	0.280	0.294
	2007m6		2008m2		2008m8	
# of branches, domestically-owned	178		181		203	
# of branches, foreign-owned	26		27		28	
<b>Subsidiaries</b>						
	Avg: 2007m1-2007m6		Avg: 2007m8-2008m2		Avg: 2008m4-2008m8	
net borrowing from parent bank / total assets	0.170	1.169	0.067	0.476	0.257	1.201
core investment role <sup>c</sup>	0.044	0.091	0.042	0.088	0.040	0.086
core funding role <sup>d</sup>	0.351	0.290	0.339	0.284	0.345	0.271
size (total assets) in € billion	5.611	9.658	5.420	9.621	5.449	10.021
short-term wholesale funding / total assets	0.315	0.279	0.283	0.260	0.247	0.237
	2007m6		2008m2		2008m8	
# of subsidiaries, domestically-owned	100		101		108	
# of subsidiaries, foreign-owned	6		3		4	

<sup>a</sup> Sum of cash holdings, claims on the central bank, short-term claims on other (unaffiliated) banks and holdings of short-term securities.

<sup>b</sup> The repo\_exposure of the parent bank is defined as the financing via repurchase agreements relative to overall short-term wholesale funding (interbank liabilities, including repo agreements with other monetary and financial institutions, own bonds and notes issued and repo liabilities to non-banks). Short-term refers to an original maturity of less than one year.

<sup>c</sup> Core investment role: share of the affiliate in the bank holding company's total lending business to the foreign non-bank private sector (measured in loan stock outstanding).

<sup>d</sup> Core funding role: affiliate's local liabilities / total liabilities.

Table 2: Descriptive statistics on host countries of German banks' affiliates

<b>Country level</b>	Obs	Mean	StD	Min	Max
<i>Before Subprime market collapse: 2007m6</i>					
euro area (excluding financial platforms)	278	0.259	0.439	0	1
financial platform	278	0.518	0.501	0	1
financial openness	278	2.039	1.035	-1.159	2.456
<i>Before Bear Stearns rescue: 2008m2</i>					
euro area (excluding financial platforms)	282	0.262	0.441	0	1
financial platform	282	0.511	0.501	0	1
financial openness	282	2.075	0.963	-1.159	2.456
<i>Before Lehman Brothers bankruptcy: 2008m8</i>					
euro area (excluding financial platforms)	311	0.283	0.451	0	1
financial platform	311	0.460	0.499	0	1
financial openness	311	2.068	0.963	-1.159	2.456

euro area (excluding financial platforms): Dummy variable: =1 if country is a euro area country but no financial platform  
*d\_euro\_area\_no\_fin\_platform*

financial platform: Dummy variable: =1 if country is a financial platform for German banks (see Table 3 "List of countries")  
*d\_fin\_platform*

financial openness: De jure financial openness indicator (Chinn and Ito (2008))  
*fin\_openness*

Table 3: List of countries with local presence of German banks

The list contains all countries in which German parent banks have established branches and/or subsidiaries. All figures are listed as of 2007m6.

(\*) marks countries which represent financial platforms for German banks (see section 4.2).

(...) stands for data not shown here on grounds of confidentiality.

Country	Aggregate size of branches and subsidiaries of German banks (in € billion)	# of parent banks operating in this country via branches and/or subsidiaries	Aggregate net borrowing of branches and subsidiaries from German parent banks (in € billion)
1 Argentina	...	1	...
2 Australia	...	2	...
3 Austria	1.847	7	-0.797
4 Belgium	9.409	6	-5.476
5 Brazil	...	2	...
6 Canada	...	2	...
7 Cayman Islands *	184.925	10	20.125
8 Chile	...	1	...
9 China	5.327	7	-0.044
10 Czech Republic	3.444	3	-0.509
11 Denmark	...	1	...
12 Finland	...	2	...
13 France	31.625	12	12.004
14 Greece	2.163	3	0.925
15 Guernsey *	...	1	...
16 Hong Kong *	33.837	7	1.193
17 Hungary	10.140	6	0.552
18 India	...	1	...
19 Indonesia	...	1	...
20 Ireland *	64.323	10	8.563
21 Italy	107.590	12	31.687
22 Japan	50.324	6	0.637
23 Jersey *	13.316	3	-0.414
24 Luxembourg *	371.387	23	-19.825
25 Malaysia	...	2	...
26 Mauritius	...	1	...
27 Netherlands	16.187	9	-1.941
28 Netherlands Antilles *	...	1	...
29 New Zealand	...	1	...
30 Pakistan	...	1	...
31 Philippines *	...	1	...
32 Poland	16.711	6	0.136
33 Portugal	6.983	4	-0.776
34 Republic of Korea	...	1	...
35 Russian Federation	3.372	4	1.362
36 Saudi Arabia	...	1	...
37 Singapore *	75.584	10	10.271
38 Slovak Republic	...	1	...
39 South Africa	...	2	...
40 Spain	30.492	9	16.983
41 Sri Lanka (Ceylon) *	...	1	...
42 Sweden	3.072	4	3.023
43 Switzerland *	26.516	11	2.221
44 Taiwan	...	1	...
45 Thailand	...	1	...
46 Turkey	...	2	...
47 United Arab Emirates	...	1	...
48 United Kingdom *	1097.080	20	100.310
49 United States *	307.444	12	16.704
50 Vietnam	...	1	...

Table 4: Regression results: subprime market collapse

The dependent variable is the change in net borrowing of the affiliate (branch or subsidiary)  $j$  from parent bank  $i$  (avg. 2007m8-2008m2 vs. avg. 2007m1-2007m6). The parent bank's *repo\_exposure* is its share of funding via repurchase agreements in overall short-term wholesale funding (defined in section 4.2) as of 2007m6. The *core investment role* is calculated as the share of the affiliate in the bank holding company's total foreign non-bank private sector lending. The *core funding role* is the affiliate's local liabilities relative to total liabilities (all affiliate variables are avg. 2007m1-2007m6). Financial platforms (dummy variable *d\_fin\_platform*) are host countries defined as important financial centers in section 4.2. The regression sample contains only German domestically owned banks. The differentiation of effects between branches and subsidiaries is obtained by interacting with a dummy variable (*d\_sub*) and by calculating total effects from that. Standard errors, clustered by parent bank, in parentheses (\*\*\*)  $p < 0.01$ , \*\*  $p < 0.05$ , \*  $p < 0.1$ .

Dependent variable	Subprime market collapse		
	(shock to funding occurs in 2007m7)		
Change in net borrowing from the parent bank	total effect branches	total effect subsidiaries	
Explanatory variables:	( <i>d_sub</i> =0)	( <i>d_sub</i> =1)	
<b>(Parent bank) repo_exposure</b>	<b>-2.091**</b>	<b>-1.743*</b>	difference: 0.349 (0.320)
	<b>(0.860)</b>	<b>(0.912)</b>	
<i>Interaction terms:</i>			
<i>Affiliate level:</i>			
repo_exposure * core investment role	14.321***	-10.463	
	(4.393)	(11.568)	
repo_exposure * core funding role	-0.460	-0.718**	
	(0.443)	(0.318)	
repo_exposure * size	-0.074*	0.057	
	(0.044)	(0.042)	
<i>Parent bank level:</i>			
repo_exposure * size		0.004	
		(0.003)	
repo_exposure * capitalization		6.182	
		(7.255)	
repo_exposure * liquidity		-0.704	
		(7.723)	
<i>Country level:</i>			
repo_exposure * d_eurozone_no_fin_platform	0.157	-0.569**	
	(0.425)	(0.043)	
repo_exposure * d_fin_platform	0.501	-0.420	
	(0.355)	(0.121)	
repo_exposure * fin_openness		-0.034	
		(0.046)	
<i>Non-interacted terms:</i>			
<i>Affiliate level:</i>			
core investment role	-0.965*	-1.065	
	(0.520)	(0.869)	
core funding role	0.292	0.106	
	(0.335)	(0.299)	
size	0.077	0.048	
	(0.050)	(0.050)	
<i>Parent bank level:</i>			
size		0.001	
		(0.002)	
capitalization		-1.130	
		(1.534)	
liquidity		-0.585	
		(0.731)	
<i>Country level:</i>			
d_euro_area_no_fin_platform	0.042	-0.118	
	(0.448)	(0.697)	
d_fin_platform	-0.522*	-0.156	
	(0.295)	(0.481)	
fin_openness		0.017	
		(0.051)	
constant		0.321	
		(0.365)	
Observations		278	
Number of parent banks (clusters)		42	
R-squared		0.336	

Table 5: Regression results: Bear Stearns rescue

The dependent variable is the change in net borrowing of the affiliate (branch or subsidiary)  $j$  from parent bank  $i$  (avg. 2008m3-2008m8 vs. avg. 2007m8-2008m2). The parent bank's *repo\_exposure* is its share of funding via repurchase agreements in overall short-term wholesale funding (defined in section 4.2) as of 2008m2. The *core investment role* is calculated as the share of the affiliate in the bank holding company's total foreign non-bank private sector lending. The *core funding role* is the affiliate's local liabilities relative to total liabilities (all affiliate variables are avg. 2007m8-2008m2). Financial platforms (dummy variable *d\_fin\_platform*) are host countries defined as important financial centers in section 4.2. The regression sample contains only German domestically owned banks. The differentiation of effects between branches and subsidiaries is obtained by interacting with a dummy variable (*d\_sub*) and by calculating total effects from that. Standard errors, clustered by parent bank, in parentheses (\*\*\*)  $p < 0.01$ , \*\*  $p < 0.05$ , \*  $p < 0.1$ .

Dependent variable	Bear Stearns rescue		difference:
	total effect branches ( <i>d_sub</i> =0)	total effect subsidiaries ( <i>d_sub</i> =1)	
Change in net borrowing from the parent bank	(shock to funding occurs in 2008m3)		
<i>Explanatory variables</i>			
<b>(Parent bank) repo_exposure</b>	<b>-3.714**</b> <b>(1.543)</b>	<b>-2.254*</b> <b>(1.219)</b>	<b>1.460**</b> <b>(0.038)</b>
<i>Interaction terms</i>			
<i>Affiliate level</i>			
repo_exposure * core investment role	19.711 (13.022)	0.669 (13.523)	
repo_exposure * core funding role	0.501 (0.659)	-1.802** (0.771)	
repo_exposure * size	0.077** (0.030)	-0.074 (0.062)	
<i>Parent bank level</i>			
repo_exposure * size		0.006** (0.002)	
repo_exposure * capitalization		20.128** (8.653)	
repo_exposure * liquidity		0.597 (3.184)	
<i>Country level</i>			
repo_exposure * d_eurozone_no_fin_platform	0.055 (0.285)	-0.803** (0.037)	
repo_exposure * d_fin_platform	-0.294 (1.716)	-0.226 (0.463)	
repo_exposure * fin_openness		0.225* (0.114)	
<i>Non-interacted terms</i>			
<i>Affiliate level</i>			
core investment role	-0.437 (0.445)	-1.162 (0.855)	
core funding role	0.068 (0.331)	0.117 (0.377)	
size	-0.084** (0.032)	0.052 (0.052)	
<i>Parent bank level</i>			
size		0.000 (0.001)	
capitalization		-1.176 (1.316)	
liquidity		-0.288 (0.567)	
<i>Country level</i>			
d_euro_area_no_fin_platform	-0.016 (0.230)	0.168 (0.36)	
d_fin_platform	0.284 (0.498)	-0.138 (0.474)	
fin_openness		-0.114* (0.061)	
constant		0.532 (0.335)	
Observations	282		
Number of parent banks (clusters)	42		
R-squared	0.155		

Table 6: Regression results: Lehman Brothers bankruptcy

The dependent variable is the change in net borrowing of the affiliate (branch or subsidiary)  $j$  from parent bank  $i$  (avg. 2008m9-2009m3 vs. avg. 2008m4-2008m8). The parent bank's *repo\_exposure* is its share of funding via repurchase agreements in overall short-term wholesale funding (defined in section 4.2) as of 2008m8. The *core investment role* is calculated as the share of the affiliate in the bank holding company's total foreign non-bank private sector lending. The *core funding role* is the affiliate's local liabilities relative to total liabilities (all affiliate variables are avg. 2008m4-2008m8). Financial platforms (dummy variable *d\_fin\_platform*) are host countries defined as important financial centers in section 4.2. The regression sample contains only German domestically owned banks. The differentiation of effects between branches and subsidiaries is obtained by interacting with a dummy variable (*d\_sub*) and by calculating total effects from that. Standard errors, clustered by parent bank, in parentheses (\*\*\*)  $p < 0.01$ , \*\*  $p < 0.05$ , \*  $p < 0.1$ .

Dependent variable	Lehman Brothers bankruptcy		
	(shock to funding occurs in 2008m9)		
Change in net borrowing from the parent bank	<i>total effect branches</i>	<i>total effect subsidiaries</i>	
Explanatory variables	( <i>d_sub=0</i> )	( <i>d_sub=1</i> )	
<b>(Parent bank) repo_exposure</b>	<b>-1.224*</b>	<b>-0.697</b>	difference: 0.526 (0.206)
	<b>(0.620)</b>	<b>(0.620)</b>	
<i>Interaction terms</i>			
<i>Affiliate level</i>			
repo_exposure * core investment role	4.114 (2.859)	-20.744 (15.055)	
repo_exposure * core funding role	0.055 (0.840)	-0.472 (0.921)	
repo_exposure * size	0.051 (0.053)	0.025 (0.132)	
<i>Parent bank level</i>			
repo_exposure * size		0.003 (0.003)	
repo_exposure * capitalization		-5.465 (6.469)	
repo_exposure * liquidity		2.922 (6.237)	
<i>Country level</i>			
repo_exposure * d_eurozone_no_fin_platform	-0.772*** (0.283)	-0.978 (0.115)	
repo_exposure * d_fin_platform	0.134 (0.627)	-1.049** (0.044)	
repo_exposure * fin_openness		0.316** (0.142)	
<i>Non-interacted terms</i>			
<i>Affiliate level</i>			
core investment role	0.447* (0.246)	0.830 (0.609)	
core funding role	-0.338* (0.175)	-0.494 (0.402)	
size	-0.044* (0.023)	0.089 (0.061)	
<i>Parent bank level</i>			
size		0.001 (0.001)	
capitalization		-1.679 (1.216)	
liquidity		-0.930*** (0.301)	
<i>Country level</i>			
d_euro_area_no_fin_platform	0.177** (0.086)	-0.204 (0.432)	
d_fin_platform	0.558** (0.208)	-0.061 (0.687)	
fin_openness		-0.062 (0.044)	
constant		0.204 (0.164)	
Observations		311	
Number of parent banks (clusters)		48	
R-squared		0.409	

Table 7: Stand-alone effect of parent banks' run-on-repo exposure

		Subprime market collapse		Bear Stearns rescue		Lehman Brothers bankruptcy	
		high repo exposure of parent (>75th percentile, average)	low repo exposure of parent (<=25th percentile, average)	high repo exposure of parent (>75th percentile, average)	low repo exposure of parent (<=25th percentile, average)	high repo exposure of parent (>75th percentile, average)	low repo exposure of parent (<=25th percentile, average)
a	average pre-period net borrowing (in € billion)	1.34	0.26	1.82	0.66	1.86	0.38
	branches						
	subsidiaries	-0.40	0.15	-0.23	0.23	0.02	0.14
b	average repo exposure of parent	0.65	0.00	0.62	0.00	0.58	0.00
c	estimated impact of repo exposure of parent on net borrowing	-2.09		-3.71		-1.22	
	branches						
	subsidiaries	-1.74		-2.25		0.00	
d (= b x c)	predicted change in net borrowing due to repo exposure (in € billion)	-1.36	0.00	-2.32	0.00	-0.72	0.00
	branches						
	subsidiaries	-1.13	0.00	-1.41	0.00	0.00	0.00
e (= d / a)	predicted change in net borrowing due to repo exposure (relative to absolute pre-period average net borrowing)	-101.19%	0.00%	-127.41%	0.00%	-38.54%	0.00%
	branches						
	subsidiaries	-280.80%	0.00%	-600.20%	0.00%	0.00%	0.00%

Table 8: Robustness: Instrumental-variables approach for Bear Stearns rescue

The dependent variable is the change in net borrowing of the affiliate (branch or subsidiary)  $j$  from parent bank  $i$  (avg. 2008m3-2008m8 vs. avg. 2007m8-2008m2). The parent bank's *repo\_exposure* is its share of funding via repurchase agreements in overall short-term wholesale funding (defined in section 4.2) as of 2008m2.

The regression is estimated using two-stage least squares. The parent bank's *repo\_exposure* is instrumented with its *repo\_exposure* as of 2007m6 (before the subprime market collapse). Likewise, other parent bank variables (size, capitalization, liquidity) are instrumented with earlier values. The model is exactly identified. Statistics on the first stage regressions (not reported) and the reported Kleinbergen-Paap rank LM-statistic for identification (which is robust to clustered standard errors) suggest that the instruments are sufficiently strong in explaining the endogenous regressors. Standard errors, clustered by parent bank, in parentheses (\*\*\*)  $p < 0.01$ , \*\*  $p < 0.05$ , \*  $p < 0.1$ ).

The *core investment role* is calculated as the share of the affiliate in the bank holding company's total foreign non-bank private sector lending; the *core funding role* is the affiliate's local liabilities relative to total liabilities (all affiliate variables are avg. 2007m8-2008m2). Financial platforms (dummy variable *d\_fin\_platform*) are host countries defined as important financial centers in section 4.2. The regression sample contains only German domestically owned banks. The differentiation of effects between branches and subsidiaries is obtained by interacting with a dummy variable (*d\_sub*) and by calculating total effects from that.

<b>Bear Stearns rescue</b>			
<i>Dependent variable</i>	<b>- two-stage least squares -</b>		
Change in net borrowing from the parent bank	(shock to funding occurs in 2008m3)		
<i>Explanatory variables</i>	<i>total effect branches</i> ( <i>d_sub</i> =0)	<i>total effect subsidiaries</i> ( <i>d_sub</i> =1)	<b>difference:</b>
<b>(Parent bank) repo_exposure</b>	<b>-4.749**</b> (1.995)	<b>-3.452**</b> (0.037)	<b>1.297**</b> (0.586)
<i>Interaction terms</i>			
<i>Affiliate level</i>			
repo_exposure * core investment role	19.112 (12.181)	-12.277 (0.455)	
repo_exposure * core funding role	0.600 (0.480)	-1.721** (0.013)	
repo_exposure * size	0.081* (0.044)	-0.119** (0.027)	
<i>Parent bank level</i>			
repo_exposure * size		0.007*** (0.003)	
repo_exposure * capitalization		17.342*** (6.550)	
repo_exposure * liquidity		3.982 (4.100)	
<i>Country level</i>			
repo_exposure * d_eurozone_no_fin_platform	0.378 (0.350)	-0.492 (0.186)	
repo_exposure * d_fin_platform	0.618 (1.685)	0.057 (0.872)	
repo_exposure * fin_openness		0.258** (0.114)	
<i>Non-interacted terms</i>			
<i>Affiliate level</i>	Yes		Yes
<i>Parent bank level</i>		Yes	
<i>Country level</i>	Yes		Yes
constant		0.987** (0.473)	
Observations		282	
Number of parent banks (clusters)		42	
R-squared		0.147	
<b>Underidentification (H0: Not identified)</b>			
Kleinbergen-Paap rank LM-statistic		9.661	
p-value (Chi-sq (1))		0.002	
<b>Exogeneity of explanatory variables (H0: Exogenous)</b>			
Robustified Durbin-Wu-Hausman test statistic		F(19,41) = 170.372	
p-value		0.000	