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Do exposures to sagging real estate, subprime or conduits abroad lead to contraction and flight to quality in bank lending at home?

Steven Ongena
(University of Zurich, Swiss Finance Institute and CEPR)

Günseli Tümer-Alkan
(VU University Amsterdam)

Natalja von Westernhagen
(Deutsche Bundesbank)

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

Tel +49 69 9566-0

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

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Non-technical summary

Research Question

By mid-2006 real estate prices in the US began to plummet, triggering the US subprime mortgage crisis that led to a global financial crisis. German banks, too, experienced considerable loan losses and ensuing capital constraints. This was largely attributed to their various exposures to the US real estate market. In addition to their direct lending to US firms in the real estate sector and to major subprime lenders, German banks also became exposed by providing liquidity support in the form of credit lines to their asset-backed commercial paper (ABCP) conduits. For that reason, we investigate how each type of exposure in the US influenced domestic lending in Germany. We focus on the heterogeneity in the contraction taking place across banks and firms. We are mainly interested in seeing whether – when home prices started to decline in the US – differences in bank exposures to the US real estate market started to determine bank lending in Germany according to firm risk.

Contribution

A number of features clearly distinguish our paper from previous work. First, having access to unique and confidential supervisory data, we know the actual time-varying exposures to the US real estate market (including direct lending to the US real estate sector and to the subprime lenders, and the indirect conduit exposure) of all German banks which, combined with the steep drop in US home prices, allows us to identify possible bank losses. Second, to identify the changes in lending we rely on credit register data that covers the entire banking sector in Germany. Finally, we examine not only the resultant aggregate volume but also the composition of bank lending in Germany across corporations, industries and regions.

Results

We first document the overall contraction in lending in Germany following the US home price shock. We find that banks with a higher exposure to the US real estate market contract their lending to German firms by more than banks that do not have such an exposure. The reduction in lending is more pronounced for borrowers in riskier industries and regions following a decrease in US home prices. When breaking down our estimations by type of exposure, we also find that this effect is driven by the direct exposure to the real estate sector and by the conduit exposure. In sum, we in effect document that possible losses abroad shift bank lending at home and that the size of this effect depends on the type and the degree of exposure the bank has.

Nichttechnische Zusammenfassung

Fragestellung

Als Mitte 2006 die Immobilienpreise in den USA zu stürzen begannen, wurde die Subprime-Krise in den USA ausgelöst, die zu einer globalen Finanzkrise geführt hat. Auch deutsche Banken erlebten erhebliche Kreditausfälle und mussten die daraus resultierenden Kapitaleinbußen verkraften. Dies war im Wesentlichen auf ihre verschiedenen Engagements am US-Immobilienmarkt zurückzuführen. Neben ihrer direkten Kreditvergabe an die US-Firmen im Immobiliensektor und an die wichtigsten Subprime-Kreditgeber wurden die deutschen Banken auch durch die Bereitstellung von Liquiditätshilfen in Form von Kreditlinien, um ihre außerbilanziellen Geschäftseinheiten zu unterstützen, dem US-Hauspreisschock ausgesetzt. Aus diesem Grund untersuchen wir, wie jede Art der US-Engagements deutscher Banken die inländische Kreditvergabe in Deutschland beeinflusst hat. Wir untersuchen vor allem die Heterogenität bei dem Rückgang der inländischen Kreditvergabe. Uns interessiert primär die Frage, ob – als die Immobilienpreise in den USA zu sinken begannen – die inländische Kreditvergabe der Banken durch die Unterschiede in ihren Engagements in dem US-Immobilienmarkt und in Abhängigkeit vom Unternehmensrisiko in Deutschland beeinflusst wurde.

Beitrag

Eine Reihe von Eigenschaften unterscheidet unser Papier eindeutig von früheren Arbeiten. Erstens ermöglicht uns der Zugang zu vertraulichen bankaufsichtlichen Einzeldaten die tatsächlichen zeitlich variierenden Engagements in dem US-Immobilienmarkt aller deutschen Banken zu bestimmen. In Kombination mit dem drastischen Rückgang der US-Immobilienpreise ermöglicht uns diese Information, die mutmaßlichen Verluste der Banken zu identifizieren. Zweitens greifen wir auf das Kreditregister zu, das den gesamten Bankensektor in Deutschland abdeckt, um die Änderungen in der Kreditvergabe zu untersuchen. Schließlich untersuchen wir nicht nur das resultierende Volumen im Aggregat, sondern auch die Zusammensetzung der Kreditvergabe der Banken in Deutschland über Unternehmen, Branchen und Regionen.

Ergebnisse

Wir dokumentieren zunächst den generellen Rückgang der Kreditvergabe in Deutschland nach dem US-Hauspreisschock. Wir finden, dass die Banken mit einer höheren Kreditvergabe an den US-Immobilienmarkt ihre Kreditvergabe an deutsche Firmen stärker nach dem Rückgang der US-Immobilienpreise reduziert haben als die Banken, die keine derartige Kreditvergabe an den US-Immobilienmarkt hatten. Der Rückgang der Kreditvergabe nach dem US-Hauspreisschock ist auch stärker bei deutschen Firmen in riskanteren Branchen und Regio-

nen. Die Schätzergebnisse nach der Art der US-Engagements zeigen, dass diese Ergebnisse überwiegend durch die direkte Kreditvergabe an den US-Immobiliensektor und durch die Conduit-Engagements getrieben sind. Wir dokumentieren somit vor allem, dass mutmaßliche Verluste im Ausland die Kreditvergabe der Banken zu Hause verlagern,während die Größe des Effekts von der Art und dem Grad der Risikoposition der Bank abhängt.

BUNDESBANK DISCUSSION PAPER NO 09/2015

Do Exposures to Sagging Real Estate, Subprime or Conduits Abroad Lead to Contraction and Flight to Quality in Bank Lending at Home?*

Steven Ongena

University of Zurich,
Swiss Finance Institute and CEPR

Günseli Tümer-Alkan

VU University Amsterdam

Natalja v. Westernhagen

Deutsche Bundesbank

Abstract

We investigate how differential exposures by German banks to the US real estate market during the recent financial crisis affect their corporate lending in Germany. Using unique bank-level exposure data, we distinguish between three different types of bank exposures, i.e. direct exposure to the US real estate sector, direct exposure to subprime lenders in the US, and indirect exposure through the liquidity provided to ABCP conduits. We find that banks with a higher exposure to the US real estate sector and to conduits cut their lending to German firms by more following a decrease in US home prices than banks that do not have such an exposure. Moreover, these banks then also shift their lending to industry–region combinations with lower insolvency ratios. Hence possible losses abroad shift bank lending at home, and the size of this effect depends on the type and the degree of exposure the bank has.

Keywords: financial sector, bank lending, real estate exposure, subprime, conduits

JEL-Classification: G01, G21, R00

* Contact addresses: Steven Ongena, University of Zurich, Swiss Finance Institute and CEPR, Plattenstrasse 14, 8032 Zurich, Switzerland, Phone: + 41 44 6342951, E-mail: steven.ongena@bf.uzh.ch; Günseli Tümer-Alkan, VU University Amsterdam, Department of Finance, De Boelelaan 1105, 1081 HV Amsterdam, The Netherlands, Phone: + 31 20 5987430, E-mail: g.tumeralkan@vu.nl; Natalja v. Westernhagen, Deutsche Bundesbank, Department of Financial Stability, Wilhelm-Epstein-Strasse 14, D-60431 Frankfurt am Main, Germany, Phone: + 49 69 95667002, E-mail: natalja.von.westernhagen@bundesbank.de. We thank Christoph Memmel, Ingrid Stein and Michael Wosser, and participants at the Deutsche Bundesbank seminar (Frankfurt) and Spring 2015 MFS Conference (Larnaca) for helpful comments. The opinions expressed in this paper are those of the authors and do not necessarily reflect the views of the Deutsche Bundesbank or their staff.

1 Introduction

By mid-2006 real estate prices in the US began to plummet, triggering the US subprime mortgage crisis that led to a global financial crisis. While the main focus was on the fragility of the financial system (and, to some extent, the regulatory focus is still on how to re-establish a healthy banking industry), the initial policy reaction relied mostly on monetary tools. These measures proved to be not entirely effective due to the presence of excessive household debt coupled with decreasing house prices. The crisis may not have been as severe, it is often argued now, if those underlying problems had have been addressed in a first and foremost step (Mian and Sufi (2014)).

German banks, too, experienced considerable loan losses and ensuing capital constraints. This was largely attributed to their various exposures to the US real estate market. In addition to their direct lending to US firms in the real estate sector and to major subprime lenders, German banks also became exposed by providing liquidity support in the form of credit lines to their asset-backed commercial paper (ABCP) conduits.

The first banks that had to be bailed out by a government during the financial crisis were actually two German banks, IKB Deutsche Industriebank and Sachsen Landesbank. The deteriorating quality of their assets and the panic on the ABCP market forced these German banks to write off the liquidity lines they had provided to their ABCP conduits. These write-offs resulted in considerable losses on their balance sheets. In general, the Landesbanks' substantial exposures to US mortgage-backed securities through their ABCP conduits, which were higher than those of the large German banks, led to the collapse or bail-out of various Landesbanks.

Given these differences, we therefore investigate how each type of exposure in the US influenced domestic lending in Germany. We first suitably document the overall contraction in lending that occurred in Germany, then focus on the heterogeneity in the contraction taking place across banks and firms. We are mainly interested in seeing whether – when home prices started to decline

in the US – differences in bank exposures to the US real estate market started to determine bank lending in Germany according to firm risk.

We are clearly not the first to study (and for identification purposes 'exploit') the international transmission of shocks through the banking sector. Our research follows the seminal work by Peek and Rosengren (1997) and Peek and Rosengren (2000) who show that when parent banks are faced with a (funding) shock, this can negatively affect lending by their foreign affiliates.[1] In particular Peek and Rosengren (1997) identify a supply shock to bank lending in the US through US branches of Japanese banks, which was caused by the decline in Japanese stock market values. Unlike the previous studies trying to examine the relationship between capital ratios and the overall volume of lending, their study actually disentangles loan supply from loan demand by focusing on the transmission of the capital effects of the Japanese stock market declines. Their paper documents that the Japanese banks' capital ratios significantly determine its commercial and industrial lending in the US. Using similar data, Peek and Rosengren (2000) investigate the change in commercial real estate loans in spatially separated markets, which enables them to examine the impact of this loan supply shock on the real economic activity in the US.

A recent paper (and closest to ours) is a paper by Puri, Rocholl and Steffen (2011). They investigate the impact of the financial crises on the credit supply of German savings banks. Here, the transmission occurs through savings banks' holdings in Landesbanks that were exposed to subprime mortgages.[2] This mechanism is somewhat different from the one in Peek and Rosengren since an external financial shock is transmitted to a domestic market through the exposure of the domestic banks. For that reason, it becomes even more important and potentially more difficult to isolate the loan supply effect. Puri, Rocholl and Steffen (2011) disentangle supply from demand effects by employing information coming from the loan application process. The authors find that affected

[1] Recent research confirms that, during the global financial crisis, global banks transmitted shocks across borders through their local affiliates (see, among others, Cetorelli and Goldberg (2011); Cetorelli and Goldberg (2012); Acharya, Afonso and Kovner (2013); Albertazzi and Bottero (2013); Claessens and van Horen (2013); Cull and Martinez Peria (2013); Ongena, Peydró and van Horen (2013); Allen, Hryckiewicz, Kowalewski and Tümer-Alkan (2014); Bertay (2014); and de Haas and van Lelyveld (2014)).

[2] Other papers studying the international transmission through the asset side of the banks include De Haas and Van Horen (2013) and Popov and Van Horen (2013). The former paper examines syndicated loans and finds that crisis-related write-downs negatively affected cross-border bank lending. The latter paper finds that large holdings of impaired sovereign debt negatively affected bank lending during the European sovereign debt crisis. Cuñat, Cvijanovic' and Yuan (2013) study the domestic transmission of real estate price shocks within the US using bank balance sheets.

savings banks reject more loan applications than non-affected banks. However, close bank-firm relationships help to mitigate the loan supply shock.

A number of features clearly distinguish our paper from Puri, Rocholl and Steffen (2011). First, having access to unique and confidential supervisory data, we know the actual time-varying exposures to the US real estate market (direct lending to the US real estate sector, to major subprime lenders, and conduit exposures) of all German banks. Combined with the US home price shock, these exposures to the US real estate market allow us to identify possible (but at the time not yet publicly observable) bank losses. In contrast, Puri, Rocholl and Steffen (2011) rely on ex post publicly reported distress at three Landesbanks which reduced the value of equity held by savings banks present in their loan data set. Thus our data set allows us to assess the time-varying effects of various types of German bank exposures to the US real estate market throughout the entire crisis period, not just the presumed (though plausible) impact through indirect linkages within parts of the German banking system.

Second, to identify the changes in lending we rely on credit register data that cover the entire banking sector in Germany, not just savings banks. We match this data with bank and market characteristics. Finally, we examine the resultant changes not only in the aggregate volume but also in the composition of bank lending in Germany across corporations, industries and regions as we want to investigate whether there is a 'flight to quality' in lending in Germany for those banks that were more exposed to the US real estate market.[3]

In terms of credit volume we find that banks that had a direct exposure to the US real estate sector contracted their lending in Germany by more following a decrease in US home prices than banks that did not have such exposure. This effect is both statistically significant and economically relevant. For example, a bank with a €1 billion exposure to the US real estate sector, and following a decrease by 5 index points (which is equal to two standard deviations) in the S&P/Case-Shiller US

[3] In this respect, our paper also contributes to an extant literature that examines the flight to quality or loan strictness following negative shocks affecting banks (Lang and Nakamura (1995); Bernanke, Gertler and Gilchrist (1996); Murfin (2012); Becker and Ivashina (2014)), or documents bank risk-taking following expansionary monetary shocks (Ioannidou, Ongena and Peydró (2014); Jiménez, Ongena, Peydró and Saurina (2014)). See also e.g. for the US (Altunbas, Gambacorta and Marquez-Ibañez (2014); Delis, Hasan and Mylonidis (2011); Paligorova and Santos (2012); Dell'Ariccia, Laeven and Suarez (2013); Buch, Eickmeier and Prieto (2014b); Buch, Eickmeier and Prieto (2014a)), Austria (Gaggl and Valderrama (2010)), Colombia (López, Tenjo and Zárate (2010a), López, Tenjo and Zárate (2010b)), the Czech Republic (Geršl, Jakubík, Kowalczyk, Ongena and Peydró (2015)), Portugal (Bonfim and Soares (2013)), and Sweden (Apel and Claussen (2012)).

National Home Price Index, is estimated to contract its quarterly lending in Germany by 1.1 percentage points more than a bank with no such exposure. This is a large effect given that the mean (median) quarterly loan growth during the sample period equals -2.0 (-1.0) percent). And a bank with €1 billion in US conduits is estimated to contract its quarterly lending in Germany by 1.0 percentage points more than banks without conduits in place following a decrease by 5 index points in home prices.

In terms of credit composition, we find clear evidence of a flight to quality. For example, a bank with a €1 billion exposure to the US real estate sector, and following a decrease by 5 index points in the S&P/Case-Shiller US National Home Price Index, is estimated to contract its quarterly lending in Germany to firms in riskier industry–region combinations (i.e. those with a 1 percentage point higher insolvency rate) by 3.3 percentage points more than a bank with no such exposure. A bank with €1 billion in US conduits is estimated to contract its quarterly lending to such riskier industry–region pairs by 2.4 percentage points more than banks without conduits in place when US home prices decrease by 5 index points. Overall, these findings imply that possible losses abroad may not only cut but also shift bank lending at home, but that the size of this effect may depend on the type of exposure the bank has.

The remainder of our paper is organized as follows. In Section II, we discuss the various exposures German banks have in the US and their lending to firms in Germany. In Section III we describe the data and the definition of the variables of interest. We discuss the methodology and present the main estimation results in Section IV. Section V concludes.

2 Exposures in the US and Lending in Germany

2.1 Bank Exposure to Real Estate, Subprime and Conduits

2.1.1 The Three Types of Exposures

German banks were engaged in at least three ways in the US real estate market: some banks had direct (regular) exposures to the US real estate sector on their balance sheets, some banks had expo-

sures to subprime lenders, and some banks had asset-backed commercial paper (ABCP) conduits in place.

Table 1 gives a detailed overview of German banks' portfolios based on the credit register data by distinguishing between on and off-balance sheet exposures in 2007. The upper panel of the table provides the regional distribution of exposures to the real estate sector, including Greece, Ireland, Portugal, Spain, offshore centers, the US and all foreign countries.[4] We can clearly see that German banks' exposure to US firms in the real estate sector was significantly higher than exposures to any of the other countries' firms in the same sector. Whereas US real estate exposure exceeds €30 billion, the second highest exposure, which is to offshore centers, totals only €13.6 billion, while the third highest, which is to Spain, equals €10.6 billion. Moreover, US real estate exposure was potentially the first to be struck by a collapse in home prices and this exposure will therefore experience the "cleanest" (identifiable) shock to real estate during the crisis.

Table 1 also breaks down the exposures by three types, i.e. on and off-balance sheet exposures and derivatives. The fraction of the on-balance sheet exposures ranges from 87 to 92 percent for all three types of exposures, which explains our later approach of focusing on these on-balance sheet exposures. The rest of the table lists the outstanding loans to US banks (€157 billion) and the total exposure to offshore centers (€148 billion). It is not surprising that the structure of lending to banks differs from the direct exposure to the real estate sector as the former consists of similar shares of on and off-balance sheet exposures due to a higher share of derivatives.

The bulk of the German banks' engagement in the US subprime mortgage market took place through the investment activities of their ABCP conduits, however.[5] For the mean bank among the 1,547 banks in our sample, direct real estate exposure in 2007Q2, for example, was equal to €17.7 million, exposure to major subprime lenders to €1.3 million, and conduit exposure to €81.3 million (Table 2). But only a few banks had such exposures. Among the 41 banks with real estate exposures, the mean (median) exposure amounted to €666.8 (€161.8) million; for the 78 banks with sub-

[4] During the eurozone crisis, Greece, Ireland and Portugal received bail-out funds of €148.6, €54.9 and €61.4 billion, respectively. Another eurozone member, Spain, experienced problems in the real estate sector reflected in decreasing house prices. Finally, exposure to offshore centers is an indication of SPV exposures.

[5] Since the credit register does not contain exposures to ABCP conduits, we do not include the information on those exposures in Table 1. The data on ABCP conduits comes from Moody's ABCP Query and is discussed in Table 2.

prime exposures, the mean (median) exposure was equal to €25 (€5) million; while for the 13 banks with conduits, the mean (median) exposure was equal to €9.7 (€5.7) billion.

2.1.2 The Asset-Backed Commercial Paper Conduits

ABCP conduits set up by German banks performed maturity transformation by purchasing long-term assets and issuing asset-backed commercial paper, a short term debt instrument which is often used to raise capital. The ABCP were primarily sold to money market funds (MMFs) and rolled over at regular intervals. Nevertheless ABCP conduits used to be off-balance sheet vehicles and represented the agents of the "shadow banking" market which appeared to be less regulated. Therefore, German banks could hold assets in their ABCP conduits without providing a sufficient amount of the required capital.

Table 1
Regional Distribution for Exposures by German Banks in 2007Q2

Type of Exposure	Unit	Total Exposure	Balance-Sheet Exposure	Off-Balance-Sheet Exposure	Derivatives
Real Estate Exposure					
Greece	€ million	284.64	269.77	14.88	0.35
Ireland	€ million	1,311.72	1,217.73	93.99	85.35
Portugal	€ million	1,715.69	1,593.12	122.57	0.55
Spain	€ million	10,613.89	9,215.53	1,398.36	28.21
Offshore Centers	€ million	13,625.11	12,193.87	1,431.23	982.51
US	€ million	31,041.15	27,337.69	3,703.47	265.95
All Foreign Countries	€ million	140,789.47	128,757.77	12,031.70	2,166.93
Banks					
US	€ million	156,898.31	84,979.48	71,918.83	56,381.09
Offshore Centers	€ million	147,931.56	96,858.99	51,072.58	27,016.96
Banks' Total Portfolio	€ million	5,350,873.61	3,707,425.18	1,643,448.43	651,867.36

This table provides the real estate exposures taken from the credit register in Greece, Ireland, Portugal, Spain, offshore centers, the US and in all foreign countries in 2007Q2 for all German banks, including the big banks and the Landesbanks. Additionally, it provides the exposure towards banks in the US, the exposure towards the offshore centers and the banks' total portfolio. The banks' total portfolio does not comprise exposures to international organisations. The table lists the total exposure, the balance-sheet exposure, the off-balance-sheet exposure and the derivatives calculated as the sum of all German banks in millions of euro. For offshore centers, the Bundesbank definition is used. According to this definition, offshore centers include 23 countries.

Table 2
Descriptive Statistics for Exposures by German Banks in the US in 2007Q2

Variable	Unit	Number of Observations	Mean	Standard Deviation	10th Percentile	25th Percentile	Median	75th Percentile	90th Percentile
All Banks									
US Real Estate Exposure	€ million	1,547	17.67	17.67	0.00	0.00	0.00	0.00	0.00
US Subprime Exposure	€ million	1,547	1.26	1.26	0.00	0.00	0.00	0.00	0.00
Conduit Exposure	€ million	1,547	81.30	81.30	0.00	0.00	0.00	0.00	0.00
Banks with US Real Estate Exposure	€ million	41	666.77	1,016.60	3.08	16.45	161.81	845.19	1,729.27
Banks with US Subprime Exposure	€ million	78	25.08	83.12	1.89	2.04	4.99	12.45	29.98
Banks with Conduit Exposure	€ million	13	9,674.29	10,361.48	55.89	2,868.42	5,686.36	15,048.98	23,711.96

This table provides the real estate, subprime and conduit exposures in the US in 2007Q2 for all German banks, including the big banks and the Landesbanks. The table lists the number of observations, mean, standard deviation, 10th percentile, 25th percentile, median, 75th percentile and 90th percentile for all exposures in millions of euro.

ABCP conduits were designed to protect investors from declines in the market value of the underlying assets. Sponsoring banks provided liquidity support to their ABCP conduits. According to Moody's (2007): *"Most programmes have 100% committed liquidity support that can be drawn to repay ABCP up to the par value of non-defaulted assets, regardless of market value."* In cases where ABCP conduits experienced difficulties, credit risk attributed to the ABCP conduits effectively put a strain on their parent banks.

Being a safe haven for investors before the crisis, ABCP conduits played a central role in the financial crisis 2007-2009 when news about the deteriorating quality of US subprime mortgages roiled the financial markets and the market for ABCP froze with risk-averse investors being unwilling to purchase and roll over maturing ABCP (Acharya and Schnabl (2010); Kacperczyk and Schnabl (2010)).[6]

Between August 2007 and the Lehman Brothers' bankruptcy in September 2008, the ABCP market was seriously stressed. In this period, the total value of ABCP outstanding decreased by 37 percent, from $1.18 trillion to $745 billion. However, the cost of issuing overnight ABCP relative to the US Federal Reserve Funds rate also jumped from 10 to 150 basis points after the news of the withdrawals from BNP Paribas. On 16 September 2008, the Reserve Primary Fund – a large MMF – announced considerable losses on its holdings of Lehman Brothers' CP. This in turn triggered a run on the MMF industry and led to the reduction of holdings of all types of CP by MMFs. After Lehman Brothers' collapse, German banks, which were already weakened by the need to meet their obligations on maturing ABCP, came under further pressure.

2.2 Lending to Domestic Firms in Germany

Credit growth in Germany has been characterized by various fluctuations since 2002. The annual growth rate of lending to domestic firms rose sharply from -0.1 percent in May 2007 to 3.8 percent in July 2008, whereas a remarkable drop was observed starting from the third quarter of 2008

[6] On 31 July, 2007, the news about the bankruptcy of the two Bear Stearns' hedge funds invested in subprime mortgages reached the market. On 7 August 2007, the French Bank BNP Paribas pronounced its withdrawals from its three funds due to an inability to judge the "fair" value of their holdings.

(Deutsche Bundesbank, *Monthly Report*, 9/2009). The annual growth in lending declined by 2.7 percentage points to 1.1 percent between July 2008 and July 2009. The rest of the euro area, on the other hand, witnessed a sharper decline in lending than Germany, and also at an earlier point in time – at the end of 2007.

The slowdown in lending is found to be situated in the non-financial industry. Growth in lending declined sharply especially for those banking groups that were hit particularly hard by the global financial crisis.

3 Data and Methodology

3.1 Data Sources

We employ a unique matched firm-bank level dataset that contains quarterly information from the 1st quarter of 2005 to the 4th quarter of 2009. The data combine five databases, i.e. the credit register (MiMik), Moody's ABCP Query, bank balance sheet data (Bista, BAKIS), regional firm insolvencies per industry and home price indices (S&P/Case-Shiller). These data sources make it possible to observe the individual lending behavior of German banks to domestic firms, and to combine this information with the exposure of German banks to the real estate sector in the US, to subprime lenders in the US, and to their conduits in the US, as well as to use the firm and bank-specific information.

The Deutsche Bundesbank's credit register (MiMik) is the main data source for the individual exposures of German banks to firms.[7] The credit register contains information on large exposures of €1.5 million (formerly 3 million Deutsche Mark) and above.[8] Therefore, exposures to small and medium-sized firms might be underrepresented in this database. However, if the sum of the exposures to firms in a borrower unit exceeds the threshold of €1.5 million, the individual exposure to a

[7] Details on the credit register can be found in Schmieder (2006), and in published work by Schertler, Buch and Westernhagen (2006), Hayden, Porath and Westernhagen (2007) and Ongena, Tümer-Alkan and von Westernhagen (2012), for example. The Bundesbank also maintains a website with working papers based on its credit register.

[8] For a more detailed definition, see Section 14 of the Banking Act (*Deutsche Bundesbank*, 2001). If exposures of €1.5 million or above existed during the reporting period but are partly or fully repaid, the remaining exposure is reported even if the amount is zero. We take the actual amounts of the exposures into consideration.

firm in that borrower unit is reported, even if it is a small exposure. This reporting partly abates the extant bias in the credit register towards medium and large-sized firms.

Bank exposures to firms in the credit register are defined fairly broadly, e.g. they include not only corporate loans but also corporate bonds.[9] In the credit register we are able to distinguish between on-balance sheet and off-balance sheet items.[10] We choose to use only on-balance sheet positions, since the inclusion of off-balance sheet exposures leads to an overstatement of the actual exposures due to guarantees provided by banks to the other banks.

Based on individual bank exposures to firms, banks and other financial institutions, the credit register covers both domestic and foreign exposures and contains the information on country code and industry classification within a particular country. This structure of the credit register allows us to identify both individual bank exposures to the real estate sector as well as to the top subprime lenders in the US, and enables us to study the impact of these exposures on the lending of German banks to domestic firms. However, although the credit register contains some information on firm quality before the 1st quarter of 2008, we augment the available information with the industry-level number of firm defaults within particular German Federal States from the Federal Statistical Office. This information on the industry number of firm defaults allows us to differentiate between the lending behavior of German banks towards firms with a worse and a higher quality.

The second database we use is the Moody's ABCP Query. From this database we take the information on all important conduits of German banks and on the amount of liquidity provision of German banks to their conduits. However, this information is available in the Moody's ABCP Query only starting in 2007. For 2005 and 2006 we hand-collect this information from two Moody's publications: "A Performance Overview for EMEA ABCP conduits" and "A Program Review for US conduits". This information allows us to study the impact of the German bank exposure to their conduits on lending behavior to domestic firms. Similar to the real estate exposure in the US and

[9] For a more detailed definition of the bank exposures, see Section 19 of the Banking Act (*Deutsche Bundesbank*, 2001). The following items are deemed not to be bank exposures: shares in other enterprises and securities in the trading portfolio.

[10] For example, lease receivables, mortgage loans, publicly guaranteed loans, and inter-bank loans (with a residual maturity of up to one year) are listed separately under on-balance sheet activities. Off-balance sheet items include derivatives (other than written option positions), guarantees assumed to cover these and other off-balance sheet transactions (*Deutsche Bundesbank*, 1998).

exposure to the subprime lenders in the US (taken from the credit register), the German bank exposure to their conduits is quarterly and is aggregated at the bank level.

We borrow the majority of our bank-specific variables from the monthly balance sheet statistics (Bista) and some of our bank-specific variables from BAKIS. BAKIS is the Information System, which is shared between the Deutsche Bundesbank and BaFin (the German Federal Banking Supervisory Office). It contains the bank balance sheets for all German banks. We select the monthly balance sheet statistics and match them with the credit register on a quarterly basis. Some risk indicators, such as e.g. non-performing loans, are not available in Bista and we extract them on a yearly basis from BAKIS.

Finally, to capture the price developments in the US real estate market, we access the S&P/Case-Shiller Home Price Indices.

3.2 Measuring Bank Exposures to Financial Shocks in the US

When measuring bank exposures to financial shocks in the US, we differentiate between direct and indirect bank exposures. Direct exposures are taken from the credit register and appear *talis qualis* on banks' balance sheets. Under indirect exposure, we consider the amount of liquidity that German banks provided to their conduits before and in the aftermath of the US crisis. These exposures are considered to be off-balance sheet and thus do not directly appear on banks' balance sheets in the event that banks' conduits run into trouble.

More precisely, we define the three different bank exposures in the US as follows: *Log US Real Estate Exposure*$_{it}$ is the logarithm of the total exposure of bank *i* in a particular quarter *t* to the US real estate sector[11]. This information is taken directly from the credit register. *US Real Estate Exposure*$_{it}$ is accumulated across individual bank-firm level exposures to the US real estate sector (and therefore varies at the bank level but does not vary across firms borrowing from the same bank when we assess the changes in lending at the bank-firm level).

[11] We take the logarithm of the exposure plus one in order to incoporate those banks which do not have any exposure to the US real estate sector. For those banks we take the logarithm of zero plus one. We use the same approach for the other exposures as well.

We also define *Log US Subprime Exposure*$_{it}$ as the logarithm of the total exposure of bank *i* in a particular quarter *t* to the subprime lenders in the US. Again this information is taken directly from the credit register. We gathered information on the top 25 subprime lenders in the US which experienced difficulties during the US mortgage crisis. However, the German banks have been exposed to 18 of these top subprime lenders.[12] *US Subprime Exposure*$_{it}$ is accumulated across the individual exposures to subprime lenders in the US and therefore varies only by bank.

Finally, we define the *Log Conduit Exposure*$_{it}$ as the logarithm of the total amount of liquidity provided by bank *i* in a particular quarter *t* to its ABCP conduits. The information on the liquidity lines is taken from Moody's ABCP Query. *Log Conduit Exposure*$_{it}$ is accumulated across individual exposures to ABCP conduits and therefore varies again only by bank. The definition and measurement of bank exposures to financial shocks in the US is summarized in Table 3.

Table 4 provides the descriptive statistics on the US real estate, subprime and conduit exposures across the dataset we employ. We have almost 4.7 million bank-firm-quarter observations of different bank exposures in the US to help us identify their impact on lending of German banks to domestic firms. Not all banks in our sample have been exposed to shocks in the US. For those banks for which we cannot find reliable direct or indirect exposures to shocks in the US, we assume that their exposure to those shocks is equal to zero. This is a reasonable assumption given the exhaustive character of our data sources.[13]

Table 4 again reflects that important German banks had considerable direct exposure to the US real estate sector. On average, US real estate exposure for banks in our sample equals €442 million with the 90th percentile value exceeding €1.6 billion. Subprime exposure, in comparison, does not carry so much weight and equals on average €36 million with the standard deviation of €124 million. Table 4 clearly shows that the magnitude of the conduit exposure – which is off-balance sheet – is of a quite different magnitude compared to direct US real estate exposure. The average for the

[12] The 18 top subprime lenders have been identified in the credit register as borrower units. In total, 123 enterprises in the credit register belong to those 18 top subprime lenders.

[13] The coverage of conduit exposures prior to 2007Q1 is very sketchy because rating agencies did not cover them as few observers anticipated bank lines of credit would be provided in their rescue.

Table 3
Variable Definitions

Variable Name	Definition and Measurement	*Data Source*
Bank-firm level variable		
Δ Log Domestic Lending	The change in the logarithm of domestic lending from time t-1 to time t by bank i to firm j	*Credit Register*
Bank level variables		
Log US Real Estate Exposure	The logarithm of total direct exposure to the US real estate sector	*Credit Register*
Log US Subprime Exposure	The logarithm of total direct exposure to subprime lenders	*Credit Register*
Log Conduit Exposure	The logarithm of liquidity provided to asset-backed commerical paper (ABCP) conduits	*Moody's*
Log Size	The logarithm of total assets	*Bank Balance Sheet Data*
Capital	The capital ratio	*Bank Balance Sheet Data*
Liquidity	The liquidity ratio	*Bank Balance Sheet Data*
ROA	The return on assets ratio	*Bank Balance Sheet Data*
NPL	The non-performing loans to total loans ratio	*Bank Balance Sheet Data*
Macro variable		
Δ US Homeprices	The change in the national US home price index	*S&P/Case-Shiller Home Price Indices*
Firm industry-region variable		
Insolvency	The number of insolvencies divided by the total number of firms in an industry and region	*Destatis Insolvency Data & Turnover Tax Statistics*

This table provides the variable name, definition, measurement and data source.

Table 4
Descriptive Statistics

Variable	Unit	Number of Observations	Mean	Standard Deviation	10th Percentile	25th Percentile	Median	75th Percentile	90th Percentile
Domestic Lending	€ million	3,863,218	3.63	16.23	0.07	0.39	1.48	3.00	7.10
US Real Estate Exposure	€ million	4,717,364	442.36	1,078.93	0.00	0.00	0.00	121.52	1,608.09
US Subprime Exposure	€ million	4,717,364	35.64	123.69	0.00	0.00	0.00	0.00	64.69
Conduit Exposure	€ million	4,717,364	1,858.30	5,278.54	0.00	0.00	0.00	25.48	5,860.55
Size	€ million	4,716,949	109,915.70	185,851.00	842.39	2,130.13	9,178.57	187,286.50	329,651.40
Capital	Percentage	4,646,156	14.00	3.57	10.30	11.50	13.29	15.59	18.50
Liquidity	Percentage	4,594,770	7.80	5.28	2.10	4.13	7.01	10.49	14.30
ROA	Percentage	4,692,037	0.79	1.03	0.21	0.45	0.73	1.03	1.28
NPL	Percentage	4,691,385	4.43	4.68	0.99	2.14	3.76	5.65	8.14
Δ US Homeprices	Index change (%)	4,477,216	-1.14	3.08	-5.22	-4.66	-1.08	1.87	3.35
Insolvency	Percentage	3,738,533	0.24	0.22	0.06	0.12	0.20	0.32	0.47

This table provides the number of observations, mean, standard deviation, 10th percentile, 25th percentile, median, 75th percentile and 90th percentile for all variables for the full sample.

banks in our sample is around €1.9 billion and the standard deviation reaches €5.3 billion which is a very large number indeed.[14]

3.3 Assessing Domestic Bank-Firm Lending In Germany

Our model explains the quarterly change in lending, representing the first difference of the logarithm of domestic lending:

$$\Delta \log \ Domestic \ \ Lending_{ijt} = log\left(Domestic \ \ Lending_{ijt}\right) - log\left(Domestic \ \ Lending_{ijt-1}\right) \quad (1)$$

where $Domestic\ Lending_{ijt}$ represents exposure of bank i to firm j in Germany in a particular quarter t.

If the exposures were fully repaid during the quarter, zero values are reported at the end of the quarter in the dataset. However, in our analysis we capture only non-zero exposures and therefore predominately focus on continuing changes in domestic lending, i.e. the "internal margin".

Table 4 shows that, in total, we have around 3.9 million bank-firm-quarter observations to assess domestic lending by banks to firms. On average, domestic bank-firm lending in our sample is around €3.6 million. We note that average domestic lending in our sample appears to be much lower compared to the average US real estate exposure, the average subprime exposure and the average conduit exposure. This is the case because large banks in particular have such exposures.

Table 5 compares the number of observations for banks with and without exposures to the real estate sector, subprime or conduits. These sub-samples are not mutually exclusive. The sub-sample of banks with real estate exposure has over 1.4 million bank-firm-quarter observations of domestic lending. The average bank-firm level amount of domestic lending in this sub-sample equals €6 million and is somewhat larger than average domestic lending for the total sample. It should be men-

[14] We acknowledge the fact that only a small number of banks were exposed as presented in Table 2. However, these banks are also the lenders to a higher number of borrowers compared to the rest of the banking industry with no exposures. This is observable in the number of observations of the exposed group to the total number as ranging from 25 to 35 percent (Table 5). In other words, these banks have an important role in overall domestic lending.

tioned that banks with conduit exposures belong to the same sub-sample. However, a couple of banks have subprime exposures although they do not have real estate exposures.

The sub-sample of banks with subprime exposure provides us with 926,000 bank-firm-quarter observations of domestic lending. The average domestic lending for this sub-sample amounts to €5.7 million. Also a number of banks do have direct exposure to the US real estate sector and provide liquidity to conduits although they do not offer loans to subprime lenders.

We note that the number of banks that provide liquidity to conduits is significantly smaller compared to the sub-samples discussed before. The sub-sample of banks with conduit exposure provides us with only around 426,000 bank-firm-quarter observations of domestic lending. Similar to the sub-samples with direct exposure to the real estate sector and the one with subprime exposure, the average for domestic lending in this sub-sample, at €5.9 million, tends to be larger than the average for the total sample.

3.4 Sample

Over the time period from the 1st quarter of 2005 to the 4th quarter of 2009 we consider 2,031 banks that provide domestic balance-sheet loans to 336,990 firms in Germany. In total we have 3.9 million bank-firm-quarter observations of domestic on-balance-sheet lending. However, a number of bank mergers took place during this time period. We carry out a merger correction procedure by creating a new separate bank after the merger.[15] Of the 2,031 banks involved, 90 banks have direct exposure to the US real estate sector, 142 banks have direct exposure to subprime lenders and 20 banks have conduit exposure.

In a final step we match the datasets discussed in Section III. A., and we end up with 2,030,417 bank-firm-quarter credit exposures. Table 6 contains their summary statistics that imply (when comparing to Table 4) that selection is fortunately minimal. It is also worth noting that the change in log domestic lending has negative mean and median values: -0.02 and -0.01, respectively.

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

Table 5
Descriptive Statistics, by Bank Exposures

Variable	Unit	Number of Observations	Mean	Standard Deviation	Number of Observations	Mean	Standard Deviation
		Banks with US Real Estate Exposure			*Banks without US Real Estate Exposure*		
Domestic Lending	€ million	1,412,731	6.08	24.54	2,450,487	2.22	7.92
US Subprime Exposure	€ million	1,827,003	90.74	185.82	2,890,361	0.81	3.45
Conduit Exposure	€ million	1,827,003	4,798.17	7,605.05	2,890,361	0.00	0.00
Size	€ million	1,826,999	271,374.60	215,268.00	2,889,950	7,842.87	13,472.22
Capital	Percentage	1,777,098	13.98	3.48	2,869,058	14.01	3.63
Liquidity	Percentage	1,826,946	7.14	4.51	2,767,824	8.23	5.68
ROA	Percentage	1,810,322	0.43	0.46	2,881,715	1.02	1.20
NPL	Percentage	1,810,322	2.95	2.37	2,881,063	5.36	5.46
		Banks with US Subprime Exposure			*Banks without US Subprime Exposure*		
Domestic Lending	€ million	925,784	5.72	24.37	2,937,434	2.97	12.55
US Real Estate Exposure	€ million	1,157,278	1,216.53	1,584.37	3,560,086	190.70	684.35
Conduit Exposure	€ million	1,157,278	5,549.67	8,876.52	3,560,086	658.34	2,331.93
Size	€ million	1,157,278	257,923.10	268,741.50	3,559,671	61,797.27	113,370.30
Capital	Percentage	1,124,986	13.68	3.28	3,521,170	14.10	3.66
Liquidity	Percentage	1,157,278	7.23	4.68	3,437,492	7.99	5.45
ROA	Percentage	1,156,479	0.46	0.39	3,535,558	0.91	1.14
NPL	Percentage	1,156,479	2.83	2.35	3,534,906	4.95	5.11
		Banks with Conduit Exposure			*Banks without Conduit Exposure*		
Domestic Lending	€ million	914,750	5.89	25.82	2,948,468	2.93	11.68
US Real Estate Exposure	€ million	1,249,293	1,175.60	1,420.14	3,468,071	178.23	770.38
US Subprime Exposure	€ million	1,249,293	123.40	212.89	3,468,071	4.03	26.66
Size	€ million	1,249,293	354,940.50	207,099.10	3,467,656	21,640.56	45,939.66
Capital	Percentage	1,241,699	14.89	3.44	3,404,457	13.67	3.56
Liquidity	Percentage	1,249,293	7.43	2.96	3,345,477	7.94	5.91
ROA	Percentage	1,241,258	0.38	0.39	3,450,779	0.94	1.14
NPL	Percentage	1,241,258	2.47	1.90	3,450,127	5.14	5.15

This table provides the number of observations, mean and standard deviation for all bank-specific variables, by bank exposures, for the full sample.

Table 6
Descriptive Statistics for the Observations Used in the Regressions

Variable	Unit	Mean	Standard Deviation	10th Percentile	25th Percentile	Median	75th Percentile	90th Percentile
All Banks								
Domestic Lending $_{t}$	€ million	3.83	14.67	0.11	0.49	1.58	3.24	7.58
Δ Log Domestic Lending $_{t}$	Logarithmic change	-0.02	0.34	-0.16	-0.04	-0.01	0.00	0.10
US Real Estate Exposure $_{t-1}$	€ million	370.30	981.40	0.00	0.00	0.00	86.74	1,309.28
Log US Real Estate Exposure $_{t-1}$	Logarithm	6.75	9.30	0.00	0.00	0.00	18.28	20.99
US Subprime Exposure $_{t-1}$	€ million	31.34	115.65	0.00	0.00	0.00	1.00	63.24
Log US Subprime Exposure $_{t-1}$	Logarithm	4.43	7.58	0.00	0.00	0.00	13.82	17.96
Conduit Exposure $_{t-1}$	€ million	1,469.02	4,536.33	0.00	0.00	0.00	0.00	4,472.07
Log Conduit Exposure $_{t-1}$	Logarithm	5.02	9.18	0.00	0.00	0.00	0.00	22.22
Size $_{t-1}$	€ million	88,691.14	160,680.90	857.53	2,081.79	7,388.21	137,105.90	307,803.90
Log Size $_{t-1}$	Logarithm	23.25	2.23	20.57	21.46	22.72	25.64	26.45
Capital $_{t-1}$	Percentage	14.15	3.50	10.30	11.67	13.60	15.78	18.83
Liquidity $_{t-1}$	Percentage	7.98	5.35	2.08	4.03	7.12	10.69	14.92
ROA $_{t-1}$	Percentage	0.77	0.63	0.25	0.51	0.74	1.02	1.25
NPL $_{t-1}$	Percentage	4.55	3.56	1.23	2.40	4.04	6.03	8.19
Δ US Homeprices $_{t}$	Index change (%)	-2.24	2.45	-5.22	-4.86	-2.60	-0.06	1.40
Insolvency $_{t-1}$	Percentage	0.24	0.21	0.06	0.11	0.20	0.31	0.46

This table provides the mean, standard deviation, 10th percentile, 25th percentile, median, 75th percentile and 90th percentile for all variables for the 2,030,417 observations used in the regressions. Δ Log Domestic Lending $_{t}$ is corrected for outliers at the 1 percentile level.

4 Explaining Domestic Bank-Firm Lending in Germany

4.1 Specifications

In Table 7 we run the growth in domestic bank lending in Germany on different types of exposures, starting with total US exposure (total exposure to the US real estate market), followed by a classification of our main variables of interest; US real estate exposure, US subprime exposure and conduit exposure, and various interactions that are introduced in different models, for the sample that consists of the 2,030,417 bank-firm-quarter credit exposures.

We are particularly interested in the interaction of the exposures with: (1) the change in US home prices to gauge the impact of this incoming shock on the volume of bank lending, on the one hand; and with (2) the change in US home prices and insolvency to gauge the impact of the incoming shock on the composition of bank lending, on the other hand.

We estimate different forms of the following specification:

$$\begin{aligned}\Delta\log \text{Domestic Lending}_{ijt} &= \beta_1 \log \text{Exposure}_{it\text{-}1} + \beta_2 \Delta\text{US Houseprices}_t + \beta_3 \text{Insolvency}_{jt\text{-}1} \\ &+ \beta_4 \log \text{Exposure}_{it\text{-}1} * \Delta\text{US Houseprices}_t + \beta_5 \log \text{Exposure}_{it\text{-}1} * \text{Insolvency}_{jt\text{-}1} \\ &+ \beta_6 \Delta\text{US Houseprices}_t * \text{Insolvency}_{jt\text{-}1} + \beta_7 \log \text{Exposure}_{it\text{-}1} * \Delta\text{US Houseprices}_t * \text{Insolvency}_{jt\text{-}1} \\ &+ \sum_{n=1}^{N} \beta_{8n} \text{Bank Controls}_{it-1n} + \alpha_i + \alpha_j + \varepsilon_{ijt}\end{aligned} \quad (2)$$

where $\Delta log\ Domestic\ Lending_{ijt}$ is the growth of domestic lending (measured as the quarter-on-quarter logarithmic change in domestic lending by banks *i* to firms *j* in quarter *t*). In terms of exposure by German banks in the US, we distinguish between $Total\ US\ Exposure_{it\text{-}1}$, $US\ Real\ Estate\ Exposure_{it\text{-}1}$, $Subprime\ Exposure_{it\text{-}1}$ and $Conduit\ Exposure_{it\text{-}1}$. $\Delta US\ Homeprices_t$ is the change in US home prices while $Insolvency_{jt\text{-}1}$ defines the firm insolvency rate at the industry-region level. The bank controls we feature are size (log of total assets), capital and liquidity ratios, ROA, and NPL.[16]

[16] All bank variables are quarterly except ROA and NPL. These two variables are only available on a yearly basis.

All specifications include comprehensive sets of bank and also firm fixed effects (α_i and α_j).[17] ε_{ijt} is the error term.

We employ sets of three specifications for each exposure type, always starting with a simple model without any interactions, a second model with the interaction of exposure and US home prices, and a third model with the double and triple interactions with insolvency.

Each third specification, and also the final one which includes the triple interaction term, can help answer one of our main research questions: "Is there a flight to quality in bank lending in Germany when home prices in the US decline, and does the strength of this effect depend on the degree of the German bank's exposure to real estate, subprime and conduits in the US?

4.2 Control Variables

We start by discussing the estimated coefficients on the control variables, after which we turn to the coefficients of main interest on the double and triple interaction terms that include exposures.

Among bank control variables, all estimated coefficients except liquidity are statistically significant throughout. Representative estimates in this regard from Model 1, for example, are for log size -0.00256***, for capital -0.25015*** and for NPL 0.06257***, respectively.[18] These estimates imply that a one standard deviation increase in the logarithm of total assets decreases the growth in lending by 0.6 percentage points (= 2.23 × -0.00256 × 100), that a one standard deviation increase in capital decreases the growth in lending by 0.9 percentage points (= 0.0350 × -0.25015 × 100), and that a one standard deviation increase in NPL increases it by 0.2 percentage points (= 0.0356 × 0.06527 × 100). For comparison, the mean growth of domestic loans across all bank-firm-quarter observations equals -2.5 percent.

[17] Because we are mainly interested in the effect of bank-level exposures over time, including bank-time fixed effects is problematic. Because few firms in Germany rely on multiple banks that are differentiated by their exposures in the US, including firm-time fixed effects equally robs the estimations of most if not all of their relevant variation. In further unreported robustness exercises we also investigate whether the effects are differentiated across bank type and across time periods but we do not find statistically significant differences.

[18] *** Significant at 1 percent, ** significant at 5 percent, and * significant at 10 percent. For convenience we will also indicate the significance levels of the estimates that are mentioned further on in the text.

Table 7
Explaining the Change in Domestic Bank Lending in Germany Following Shocks to Exposures in the US

Model	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*
Log Total US Exposure $_{t-1}$	-0.00038**	-0.00030*	-0.00031*									
	[0.000]	[0.000]	[0.000]									
Log Total US Exposure $_{t-1}$ * Δ US Homeprices $_{t}$		0.00829**	0.00842**									
		[0.004]	[0.003]									
Log Total US Exposure $_{t-1}$ * Insolvency $_{t-1}$			-0.01717									
			[0.016]									
Log Total US Exposure $_{t-1}$ * Δ US Homeprices $_{t}$ * Insolvency $_{t-1}$			1.86401***									
			[0.722]									
Log US Real Estate Exposure $_{t-1}$				-0.00037*	-0.00028	-0.0003						
				[0.000]	[0.000]	[0.000]						
Log US Real Estate Exposure $_{t-1}$ * Δ US Homeprices $_{t}$					0.01078***	0.01129***						
					[0.004]	[0.004]						
Log US Real Estate Exposure $_{t-1}$ * Insolvency $_{t-1}$						-0.05522						
						[0.037]						
Log US Real Estate Exposure $_{t-1}$ * Δ US Homeprices $_{t}$ * Insolvency $_{t-1}$						3.19112**						
						[1.249]						
Log US Subprime Exposure $_{t-1}$							-0.00004	0.00004	0.00003			
							[0.000]	[0.000]	[0.000]			
Log US Subprime Exposure $_{t-1}$ * Δ US Homeprices $_{t}$								0.00628	0.00617			
								[0.004]	[0.004]			
Log US Subprime Exposure $_{t-1}$ * Insolvency $_{t-1}$									0.00778			
									[0.036]			
Log US Subprime Exposure $_{t-1}$ * Δ US Homeprices $_{t}$ * Insolvency $_{t-1}$									0.60783			
									[1.547]			
Log Conduit Exposure $_{t-1}$										0.00023	0.00031	0.0003
										[0.000]	[0.000]	[0.000]
Log Conduit Exposure $_{t-1}$ * Δ US Homeprices $_{t}$											0.00958**	0.01031**
											[0.004]	[0.004]
Log Conduit Exposure $_{t-1}$ * Insolvency $_{t-1}$												-0.06933**
												[0.034]
Log Conduit Exposure $_{t-1}$ * Δ US Homeprices $_{t}$ * Insolvency $_{t-1}$												2.32069*
												[1.389]
Δ US Homeprices $_{t}$	-0.10475***	-0.16907***	-0.16965***	-0.10203***	-0.09809***	-0.09740***	-0.10278***	-0.10431***	-0.10368***	-0.10163***	-0.09915***	-0.09871***
	[0.029]	[0.014]	[0.014]	[0.029]	[0.029]	[0.029]	[0.029]	[0.030]	[0.030]	[0.029]	[0.029]	[0.029]
Insolvency $_{t-1}$	-0.13519	-0.13871	0.0067	-0.12774	-0.12322	-0.18176	-0.12921	-0.12713	-0.19256	-0.12526	-0.12165	-0.16681
	[0.174]	[0.174]	[0.232]	[0.175]	[0.176]	[0.172]	[0.175]	[0.175]	[0.170]	[0.176]	[0.177]	[0.173]
Δ US Homeprices $_{t}$ * Insolvency $_{t-1}$			-31.21701***			-12.96872*			-13.76486*			-14.11217*
			[8.860]			[7.495]			[7.955]			[7.454]

Log Size $_{t-1}$	-0.00256***	-0.00253***	-0.00255***	-0.00122*	-0.00116*	-0.00118*	-0.00250***	-0.00254***	-0.00255***	-0.00337***	-0.00336***	-0.00336***
	[0.000]	[0.000]	[0.000]	[0.001]	[0.001]	[0.001]	[0.000]	[0.000]	[0.000]	[0.001]	[0.001]	[0.001]
Capital $_{t-1}$	-0.25015***	-0.25440***	-0.25340***	-0.24876***	-0.25044***	-0.24978***	-0.24938***	-0.24953***	-0.24888***	-0.25383***	-0.25503***	-0.25426***
	[0.030]	[0.028]	[0.028]	[0.031]	[0.029]	[0.029]	[0.030]	[0.030]	[0.030]	[0.033]	[0.032]	[0.032]
Liquidity $_{t-1}$	0.00869	0.01053	0.0106	0.00947	0.00977	0.00983	0.00871	0.00917	0.00929	0.00666	0.00676	0.00688
	[0.014]	[0.014]	[0.014]	[0.014]	[0.014]	[0.014]	[0.014]	[0.014]	[0.014]	[0.013]	[0.013]	[0.013]
ROA $_{t-1}$	0.24132*	0.26600*	0.26755*	0.22911*	0.23085*	0.23116*	0.23994*	0.24662*	0.24657*	0.24024*	0.24613*	0.24639*
	[0.139]	[0.145]	[0.145]	[0.136]	[0.134]	[0.134]	[0.138]	[0.139]	[0.139]	[0.139]	[0.139]	[0.139]
NPL $_{t-1}$	0.06527***	0.05980***	0.05960***	0.06692***	0.06503***	0.06476***	0.06576***	0.06552***	0.06517***	0.06538***	0.06300***	0.06274***
	[0.024]	[0.023]	[0.023]	[0.024]	[0.024]	[0.024]	[0.024]	[0.024]	[0.024]	[0.025]	[0.024]	[0.024]
Constant	-0.00608***	-0.00664***	-0.00652***	-0.00936***	-0.00931***	-0.00924***	-0.00932***	-0.00934***	-0.00926***	-0.00933***	-0.00925***	-0.00918***
	[0.001]	[0.001]	[0.001]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
Bank Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Firm Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	2,030,417	2,030,417	2,030,417	2,030,417	2,030,417	2,030,417	2,030,417	2,030,417	2,030,417	2,030,417	2,030,417	2,030,417
R-squared	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Difference in Change in Domestic Bank Lending in Germany Between Banks That Have the Indicated Exposure in the US and That Have No Such Exposure												
€1 Billion in Total US Exposure $_{t-1}$	**-0.0079**	**-0.0062**	**-0.0064**									
€1 Billion in US Real Estate Exposure $_{t-1}$				**-0.0077**	-0.0058	-0.0062						
€100 Million in US Subprime Exposure $_{t-1}$							-0.0007	0.0007	0.0006			
€1 Billion in Conduit Exposure $_{t-1}$										0.0048	0.0064	0.0062
Additional Difference in Change in Domestic Bank Lending in Germany Following a 5 Index Point Decrease in US Homeprices Between Banks That Have the Indicated Exposure in the US and That Have No Such Exposure												
€1 Billion in Total US Exposure $_{t-1}$		**-0.0086**	**-0.0087**									
€1 Billion in US Real Estate Exposure $_{t-1}$					**-0.0112**	**-0.0117**						
€100 Million in US Subprime Exposure $_{t-1}$								-0.0058	-0.0057			
€1 Billion in Conduit Exposure $_{t-1}$											**-0.0099**	**-0.0107**
Additional Difference in Change in Domestic Bank Lending to Firms in Industries-Regions With a 1 %p Higher Insolvency Rate in Germany Between Banks That Have the Indicated Exposure in the US and That Have No Such Exposure												
€1 Billion in Total US Exposure $_{t-1}$			-0.0036									
€1 Billion in US Real Estate Exposure $_{t-1}$						-0.0114						
€100 Million in US Subprime Exposure $_{t-1}$									0.0014			
€1 Billion in Conduit Exposure $_{t-1}$												**-0.0144**
Additional Difference in Change in Domestic Bank Lending to Firms in Industries-Regions With a 1 %p Higher Insolvency Rate in Germany Following a 5 Index Point Decrease in US Homeprices Between Banks That Have the Indicated Exposure in the US and That Have No Such Exposure												
€1 Billion in Total US Exposure $_{t-1}$			**-0.0193**									
€1 Billion in US Real Estate Exposure $_{t-1}$						**-0.0331**						
€100 Million in US Subprime Exposure $_{t-1}$									-0.0056			
€1 Billion in Conduit Exposure $_{t-1}$												**-0.0240**

The dependent variable is the quarter-on-quarter logarithmic change in domestic lending by banks to firms (Δlog Domestic Lending) and an ordinary least squares estimation is used. Table 2 contains all variable definitions. In our estimations, the measurement for Insolvency, Capital, Liquidity, ROA and NPL are in ratios. Coefficients are listed in the first row, robust standard errors clustered at bank level are reported in the row below, and the corresponding significance levels are adjacent to the coefficient. "Yes" indicates that the set of fixed effects is included. *** Significant at 1%, ** significant at 5%, * significant at 10%.

Next we discuss the estimated coefficients on the variables the exposures will be interacted with, i.e. the variable that captures the change in US home prices and the variable *Insolvency*. The coefficient for the change in US home prices is negative and significant in all models ranging between -0.09740*** and -0.1695***, and equal to -0.09701*** in the last specification. This latter estimate implies that a 5 index point decrease in US home prices (which is the largest drop that is observed but one that occurs in more than one quarter of the observations) increases the growth in domestic lending by 0.5 percentage points (= 0.05 × 0.09701) in the last model that controls for all exposures.

These estimates suggest that a substitution effect may be taking place whereby home price declines in the US *per se* may lead to more lending in Germany overall. Although the magnitude of this effect is not that large, our estimates of coefficients on the double and triple interactions with this variable presented below may gain further credence as this substitution effect (as we will see) is overturned when banks have exposures in the US.

With respect to the insolvency ratio of the borrower's region and industry, it decreases the growth in lending as expected. The coefficient is negative in all but one specification, but it is statistically insignificant.

The interaction term of the change in US home prices and insolvency appears to have an inverse relationship with the change in lending. This implies that the substitution effect may be dominating the tendency for "flight to quality".

4.3 Main Effects of Exposures

Let us now turn to the exposures and their interactions. Before investigating the three types that are directly related to the origins of the crisis, we estimate our model with the total exposure to the US real estate market that is the sum of the three types. We observe in the first three models in Table 7 that an increase in total US exposure decreases growth in domestic lending. In Model 1 the estimated coefficient equals -0.00038***. As the lower panel in Table 7 (which details the economic relevancy assessment calculations) indicates, this estimate implies that a bank with a €1 billion total

exposure to the US is estimated to contract its quarterly lending in Germany by 0.8 percentage points more than a bank with no such exposure.[19] Its interaction with changes in US home prices (0.00829**) implies an additional difference of 0.9 percentage points following a decrease by 5 index points in the S&P/Case-Shiller US National Home Price Index. This is our first main finding: German bank exposure to the US real estate market, and the possible losses emanating there as real estate prices in the US sagged, substantially contracted bank lending in Germany. A direct link in terms of credit volume.

Next, in Model 3 we introduce insolvency as a measure of ex ante credit risk at the industry–region level. The interactions of insolvency with the aforementioned terms are of main interest. The estimated coefficient on the double interaction term of exposure and insolvency equals -0.01717, while the estimated coefficient on the triple interaction term of exposure, US home prices and insolvency equals 1.86401***. The triple interaction implies that, following a decrease by 5 index points in US home prices, a bank with a €1 billion exposure to the US real estate market contracts its quarterly lending to firms in Germany in riskier industry–region combinations (i.e. those with a 1 percentage point higher insolvency rate) by an additional 1.9 percentage points more than a bank with no such exposure. This is our second main finding: German bank exposure to the US real estate market overall and the possible losses emanating there as real estate prices in the US sagged, substantially shifted bank lending in Germany. A direct link in terms of credit composition, and clear evidence for a flight to quality.

4.3.1 Real Estate

Total US exposure is defined as the sum of the exposures to the US real estate market and consists of direct lending to the real estate sector and the subprime lenders, and the indirect conduit exposure. However, we would also like to focus on each particular type of exposure that is linked to different aspects of the problems in the real estate sector in the US. Therefore it is of great interest

[19] To assess economic relevancy, we rely on the amounts of €1 billion for total US exposure, real estate and conduit exposures and €100 million for subprime exposure. This choice ensures ease and clarity of exposition, but it also broadly respects the absolute and relative order of magnitudes of the standard deviations and means of the exposure variables (see Table 6). The standard deviation on real estate exposure equals €1 billion and on subprime €116 million. On conduits, the standard deviation equals €4.5 billion, while its mean equals €1.5 billion.

to examine a direct exposure to the US real estate sector in order to have a cleaner measure. We first observe in Models 4, 5 and 6 in Table 7 that US real estate exposure *per se* does not explain much of the changes in domestic lending, but that its interaction with US home prices in Model 5 strongly does. In the latter model, the estimated coefficient on the interaction equals 0.01078***. This estimate implies that a bank with a €1 billion exposure to the US real estate sector, and following a decrease by 5 index points in the S&P/Case-Shiller US National Home Price Index, is estimated to contract its quarterly lending in Germany by 1.1 percentage points more than a bank with no such exposure.[20] This effect is slightly larger than the estimated coefficient in the previous set of exercises with total US exposure.

The coefficient on the double interaction term of exposure and insolvency has a larger magnitude (-0.05522), however it is imprecisely estimated. The coefficient on the triple interaction term of exposure, US home prices and insolvency equals 3.19112**. Following a decrease by 5 index points in US home prices, a bank with a €1 billion exposure to US real estate is estimated to contract its quarterly lending in Germany to riskier firms by an additional 3.3 percentage points more than a bank with no such exposure. This is clearly a larger economic effect compared to the one found for total exposure to the US real estate market suggesting that the direct link in terms of credit composition exists and may comprise a large part of the exposure effect.

4.3.2 Subprime

In Models 7 to 9 in Table 7 we replace real estate with subprime exposure (which, as mentioned previously, is to subprime lenders and distinct from real estate exposure). All relevant estimated coefficients are imprecisely estimated probably due to the smaller amounts of exposures involved and the fact that fewer banks have such exposures.

Yet, the signs of most coefficients are as expected. For example, the estimates in Model 9 imply that a bank with a €100 million exposure to subprime lenders, and following a decrease by 5 index points in US home prices, contracts its quarterly lending in Germany by 0.6 percentage points overall, and to riskier firms by 0.6 percentage points more than a bank with no such exposure.

[20] Notice that for more than half the sample observations, the German banks involved have zero real estate exposure in the US, marking these banks to be at once a relevant and ideal control group.

Hence once more credit volume and composition in Germany are affected by the possible losses that emanate from exposures combined with home price declines in the US.

4.3.3 Conduits

Finally, in Models 10 to 12 in Table 7 we introduce conduit exposure. This exposure is very large. Indeed, the liquidity potentially provided to conduits is three times as high as US real estate exposure on average, and much larger than the amount lent to subprime lenders in our sample. However, we do not find evidence to argue that conduit exposure itself has an impact on lending in Germany. Yet the estimates in Model 11 show that a contraction in domestic lending is again spurred by US home prices dropping. A bank with a €1 billion exposure cuts lending by 1.0 percentage points more following a decrease by 5 index points in US home prices than a bank with zero exposure.[21]

Finally, in Model 12 the estimated additional coefficients further imply that a bank with €1 billion in US conduits contracts its quarterly lending to riskier firms in Germany by 1.4 percentage points more than banks without conduits in place, with the additional home price effect resulting in a contraction of 2.4 percentage points.

In sum, credit volume and composition in Germany are affected by the possible losses that emanate from exposures, combined with US home price declines, on real estate, subprime and conduits in the US.

4.4 Robustness

Our identification strategy relies on bank and bank-time level variation in exposures in the US, coupled with firm fixed effects that account for firm-level demand in Germany. Due to the lack of multiplicity in relationships, i.e. few German firms engage multiple banks, including firm-quarter fixed effects removes all the variation we are interested in. However, to account for time varying firm-level demand, we generate "firm-size times year" fixed effects. We proxy firm size with the

[21] Conduits may not have entirely been invested in real estate or at all. For example, "credit arbitrage" ABCP conduits invested heavily in securitized assets, such as asset-backed securities backed by residential mortgages and commercial mortgages, and were consequently more exposed to subprime US residential mortgage loans than other types of conduits. Other ABCP conduits, such as "multi-seller" or "single-seller" conduits, had primarily funded unsecured receivables by the time the financial crisis arrived. It is currently impossible for us to distinguish between the different types of assets present in the conduits.

sum of total bank borrowing at firm level, and use the distribution of this variable to generate ten different percentile dummies. For each size percentile we then generate a set of year-specific fixed effects.

The results remain mainly unaffected for total exposure to the US real estate market in terms of the level and the double interactions whereas we lose significance for the triple interaction and overall for direct real estate exposures. We have to note that when including firm size-year fixed effects, all bank controls are imprecisely estimated as well.

However, we do observe a much stronger effect for conduit exposure. Conduit exposure itself actually leads to a contraction in lending in Germany. This finding likely results from the sudden realization at the onset of the financial crisis that conduits "could come crashing back on the banks' balance sheets" (actually optimal given potential reputational losses in, e.g. Segura (2014)), and banks taking appropriate action in terms of lending in Germany.

The estimated coefficient of -0.00171*** in Model 4 implies that a bank with €1 billion in US conduits is estimated to contract its quarterly lending in Germany by 3.5 percentage points more than banks without conduits in place. The double and triple interactions point to the same direction with magnitudes of three to five times higher than previously estimated. For instance, in the final model, the coefficient for the triple interaction of 8.19237* implies that, following a decrease by 5 index points in US home prices, a bank with a €1 billion exposure to conduits is estimated to contract its quarterly lending in Germany to riskier firms by an additional 8.3 percentage points more than a bank with no such exposure. Finally, in Model 5 we include all three exposures at once and find the results are mostly confirmed.

Table 8
Robustness: Explaining the Change in Domestic Bank Lending in Germany

	Model	*1*	*2*	*3*	*4*	*5*
Log Total US Exposure $_{t-1}$		-0.00090***				
		[0.000]				
Log Total US Exposure $_{t-1}$ * Δ US Homeprices $_{t}$		0.00417**				
		[0.002]				
Log Total US Exposure $_{t-1}$ * Insolvency $_{t-1}$		-0.03483***				
		[0.013]				
Log Total US Exposure $_{t-1}$ * Δ US Homeprices $_{t}$ * Insolvency $_{t-1}$		0.79737				
		[0.585]				
Log US Real Estate Exposure $_{t-1}$			-0.0001			-0.0001
			[0.000]			[0.000]
Log US Real Estate Exposure $_{t-1}$ * Δ US Homeprices $_{t}$			0.03183			0.03367
			[0.031]			[0.032]
Log US Real Estate Exposure $_{t-1}$ * Insolvency $_{t-1}$			-0.01652			-0.01939
			[0.097]			[0.097]
Log US Real Estate Exposure $_{t-1}$ * Δ US Homeprices $_{t}$ * Insolvency $_{t-1}$			4.05823			4.19545
			[3.364]			[3.337]
Log US Subprime Exposure $_{t-1}$				-0.0003		-0.00036*
				[0.000]		[0.000]
Log US Subprime Exposure $_{t-1}$ * Δ US Homeprices $_{t}$				-0.01199		-0.01068
				[0.011]		[0.011]
Log US Subprime Exposure $_{t-1}$ * Insolvency $_{t-1}$				0.01255		0.00999
				[0.044]		[0.044]
Log US Subprime Exposure $_{t-1}$ * Δ US Homeprices $_{t}$ * Insolvency $_{t-1}$				-1.4123		-1.09746
				[1.449]		[1.396]
Log Conduit Exposure $_{t-1}$					-0.00171***	-0.00171***
					[0.001]	[0.001]
Log Conduit Exposure $_{t-1}$ * Δ US Homeprices $_{t}$					0.14168***	0.14399***
					[0.037]	[0.037]
Log Conduit Exposure $_{t-1}$ * Insolvency $_{t-1}$					-0.35210***	-0.34971***
					[0.106]	[0.107]
Log Conduit Exposure $_{t-1}$ * Δ US Homeprices $_{t}$ * Insolvency $_{t-1}$					8.19237*	8.04331*
					[4.588]	[4.651]
Δ US Homeprices $_{t}$		-0.20427***	-0.16209***	-0.15350***	-0.18728***	-0.18337***
		[0.022]	[0.030]	[0.028]	[0.034]	[0.031]
Insolvency $_{t-1}$		0.56247***	0.17726	0.16234	0.22588	0.2216
		[0.181]	[0.155]	[0.164]	[0.160]	[0.164]
Δ US Homeprices $_{t}$ * Insolvency $_{t-1}$		-22.97030***	-15.01474**	-13.62705**	-18.55870***	-18.27148***
		[5.972]	[5.960]	[6.091]	[5.229]	[5.458]
Constant		Yes	Yes	Yes	Yes	Yes
Bank Controls		Yes	Yes	Yes	Yes	Yes
Bank FE		Yes	Yes	Yes	Yes	Yes
Firm Size-Year FE		Yes	Yes	Yes	Yes	Yes
Observations		2,030,417	2,030,417	2,030,417	2,030,417	2,030,417
R-squared		0.030	0.030	0.030	0.030	0.030

The dependent variable is the quarter-on-quarter logarithmic change in domestic lending by banks to firms (Δ log Domestic Lending) and an ordinary least squares estimation is used. Table 2 contains all variable definitions. Coefficients are listed in the first row, robust standard errors clustered at bank level are reported in the row below, and the corresponding significance levels are adjacent to the coefficient. "Yes" indicates that the set of fixed effects is included. *** Significant at 1%, ** significant at 5%, * significant at 10%.

5 Conclusion

Motivated by the seminal works of Peek and Rosengren (1997) and Peek and Rosengren (2000), we study the international transmission of shocks through the German banking sector during the recent turmoil. In particular, using unique German bank exposure data, we investigate how exposures to the US real estate market influenced domestic lending in Germany. We are interested in total bank exposure to the US real estate market and its three salient components: direct exposures to the US real estate sector and to the subprime lenders in the US, and indirect exposure as liquidity provided to ABCP conduits.

Confirming previous studies on the transmission of shocks, we first document the overall contraction in lending in Germany following the home price shock. Our main aim is, however, to explore the heterogeneity in the contraction across banks and firms. In other words, we investigate whether differences in bank exposures to the US determine domestic lending in Germany when home prices started to decline in the US, and whether there is a 'flight to quality' in lending for those banks that were more exposed to the US real estate market.

We indeed find that banks with higher total exposure to the US real estate market and, in particular, with higher exposure to the US real estate sector and to conduits contract their lending to German firms more following a decrease in US home prices than banks with no such exposure. Moreover, these banks also prefer lending to industry–region combinations with lower insolvency ratios, especially following a decrease in US home prices. To sum up, we mainly document that possible losses abroad shift bank lending at home whereas the size of the effect depends on the type and the degree of exposure the bank has.

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