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From financial to real economic crisis: Evidence from individual firm–bank relationships in Germany*

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Abstract:

What began as a financial crisis in the United States in 2007–2008 quickly evolved into a massive crisis of the global real economy. We investigate the importance of the bank lending and firm borrowing channel in the international transmission of bank distress to the real economy—in particular, to real investment and labor employment by nonfinancial firms. We analyze whether and to what extent firms are able to compensate for the shortage in loan supply by switching banks and by using other types of financing. The analysis is based on a unique matched data set for Germany that contains firm-level financial statements for the 2004–2010 period together with the financial statements of each firm's relationship bank(s). We use instrumental variable estimations in first differences to eliminate firm- and bank-specific effects. The first stage results show that banks that suffered losses due to proprietary trading activities at the onset of the financial crisis reduced their lending more strongly than non-affected banks. In the second stage, we find that firms whose relationship banks reduce credit supply downsize their real investment and labor employment significantly. This effect is larger for firms that are unable to provide much collateral. We document that firms partially offset reduced credit supply by establishing new bank relationships, using internal funds, and issuing new equity.

Keywords: financial crisis; contagion; credit rationing; relationship lending; investment

JEL Classification: D22; D92; E44; G01; G20; G31; H25; H32

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1 Introduction

The 2007–2008 financial crisis led to a significant decline in economic output and left the U.S. economy injured. In particular, the crisis caused a significant drop in aggregate investment, resulting in a total capital stock well below its trend path (Hall 2010, 2014). Because capital adjustment is sluggish, this shortfall in real investment during the time of crisis has major long-term consequences for the economy, potentially impeding output and employment for several years into the future.

There has been a vigorous debate about whether the U.S. financial crisis also propagated to the banking sector of other countries and about the role of multinational banks in the transmission process. Allen et al. (2012) and Popov and Udell (2012) show that the activities of bank subsidiaries outside the United States are affected by the parent bank's fragility, its losses with respect to financial assets, and its reliance on interbank lending. However, because of data restrictions, tracing these effects from the bank to the firm level was difficult. Thus, knowledge of how the financial crisis impaired the real economy outside the United States is still very limited. Understanding whether events such as the U.S. financial crisis affect the real economy in other countries through the bank lending and firm borrowing channel has important implications for both the design of financial regulation and crisis management as well as the modeling of financial crises. In particular, it is important to understand the implications of globalization in banking for firm investment and capital stock; a variable through which the financial crisis has had the most enduring impact on growth of the postcrisis economy (Hall 2014).

Thus, the goal of this paper is to understand whether a substantial shock to the financial sector (e.g., the U.S. subprime mortgage crisis of 2007–2008) affects credit supply and firm investment behavior in a foreign country with stable economic performance, even if the given country's real economy is not directly affected by the initial crisis. We dig deeper by also studying the kinds of firms that are affected most by a potential credit rationing. For the first time in the literature, we are able to assess whether firms are able to mitigate credit rationing in such situations by switching banking partners, by using internal funds, or by issuing new equity.

We address these questions by focusing on the German economy, which is ideally suited to provide novel and substantive insights for various reasons. First, Germany did not undergo a housing market bubble in the 2000s; unlike in the United States or other European countries, there was no significant increase and rapid decline of German housing prices during this

period. Second, Germany experienced a period of stable economic performance with a record-low level of unemployment until 2008, so we do not have to worry about negative domestic demand effects at the beginning of the financial crisis. Third, some German banks had significant exposure to the U.S. subprime market and were substantially affected by the financial crisis (see, e.g., Bertaut et al. 2012). Last not least, Germany is relevant as the largest single economy in Europe and the fifth largest economy in the world.

Our empirical strategy proceeds as follows. We exploit a unique matched database containing firm-level financial statements for the 2004–2010 period along with the financial statements of the bank(s) with which the given firm had a lending relationship. This enables us to study whether banks that were affected at the onset of the financial crisis (because of losses from proprietary trading activities) reduced lending to firms relatively more than unaffected banks. We are able to distinguish the effect of credit supply from credit demand using an instrumental variable (IV) approach, in which our instruments capture a bank's intensity of exposure to the 2007–2008 U.S. financial crisis. We then study whether a bank's contraction in loan supply translates into lower investment rates by the firms that have a lending relationship with that bank, holding firms' investment opportunities constant. The fact that we observe each firm's banking relationships and financial statements enables us to study whether and how firms mitigate the shortage in loan supply by establishing new banking relationships and by using alternative sources of financing.

Our data cover firms of all sizes, including small and medium-sized enterprises, which are of major importance to the German economy. This broad coverage benefits our analysis in two ways: First, the data allow us to identify the kinds of firms for which external debt and equity are imperfect substitutes and which are thus affected most by a contraction in credit supply.[3] We explore three dimensions of firm characteristics suggested as important drivers of firms becoming financially constrained: firm size, age (Hadlock and Pierce 2010), and tangibility of assets (Hart and Moore 1994; Almeida and Campello 2007). Our analysis sheds light on the role of informational asymmetries in explaining the importance of relationship bank lending. Whether relationship lending has made German firms more vulnerable to shocks to the banking sector in the aftermath of the U.S. financial crisis is an open question that deserves further inquiry (Ivashina and Scharfstein 2010). Second, we can study the various adjustment channels firms might use to mitigate credit rationing by their relationship

[3] For the different reasons of imperfect capital substitutability see, e.g., Modigliani and Miller (1958), Myers (1977), Jensen and Meckling (1976), Myers and Majluf (1984), and Jensen (1986). The relevance of imperfect substitutability of debt and equity for firms' investment decision is highlighted by, e.g., Fazzari et al. (1988), Hoshi et al. (1991), Kaplan and Zingales (1997), Lamont (1997), and Rauh (2006), and for the impact of corporate payout taxation by Becker et al. (2013).

banks. In particular, the wide variety of firms in our data allows us to document important differences across firms in the ability to compensate for a loss in bank credit by switching to other banks or resorting to internal funds and new equity.

Our analysis yields five main empirical findings. First, banks with large losses from proprietary trading and significant exposure to the 2007–2008 U.S. financial crisis reduced their loan supply in Germany. Thus, the U.S. financial crisis propagated to the German economy through multinational banks. Second, a contraction in overall loan supply from a firm's relationship bank(s) translates into lower firm borrowing. This suggests that relationship lending is important in Germany and cannot easily be replaced with loans from other banks. We estimate that from 2007 to 2008, the financial crisis caused a decrease in the growth rate in debt financing of firms by half due to relationship banks' losses from proprietary trading. Moreover, we find that the effects of a reduction in banks' long term credit supply on firms' capital structure is even three times stronger than is the impact of a change in banks' overall credit supply.

Third, firm investment rates respond to a contraction in credit supply: if firms' relationship banks decrease their credit supply, firms have to reduce their real investment. Because our IV approach purges any demand effects on the part of the firm from the regression, this response shows that shocks in the financial sector transmit to the real economy. Overall, the mean net real investment rate of nonfinancial firms in Germany decreased by one-fifth in 2008 because of losses from proprietary trading that their relationship banks suffered during the financial crisis. Fourth, firms with a lower tangibility of assets are more strongly affected by a reduction of loan supply, *ceteris paribus*, because they cannot provide as much collateral. Fifth, firms partly mitigate the contraction in loan supply by establishing new bank relationships and by resorting to self-financing. More specifically, firms are able to offset almost half of the reduction in debt financing by using their accumulated liquid assets (this accounts for 49% of the overall adjustment), reducing dividend payments (46%), and increasing nominal capital (5%). Firms differ in their ability to mitigate contractions in loan supply and in the adjustment channels they use. Dividend paying firms cut back their dividends. Large firms and firms with high asset tangibility are more likely to establish new bank relationships, and the former are also more likely to issue new equity. Small firms instead rely on accumulated cash. A firm's ability to establish new bank relationships thus appears to positively depend on the quality of information available about the firm. Thereby, our findings speak to the question of why firms incur stricter publication requirements and become public. All of our results are robust to specification choices.

Our first contribution to the literature is to show the partial substitutability of banking partners and the ability of firms to switch between different sources of finance such as external and internal funds. We also provide evidence for firm heterogeneity in the capacity to compensate for a loss in loan supply. To the best of our knowledge this is the first study to provide comprehensive micro-data evidence on this issue.[4]

As a second contribution, our paper adds to the nascent literature on the relationship between banks' securities trading and their lending behavior during a crisis (Shleifer and Vishny 2010; Diamond and Rajan 2011; Abbassi et al. 2015). We show that banks suffering losses from proprietary trading cut down their loan supply more heavily than other banks.

Our third contribution to the literature is in presenting evidence on the effects of the 2007–2008 financial crisis on corporate lending.[5] While it is documented that banks sharply curtailed lending to the corporate sector during the financial crisis (e.g., in the U.S. context, see Ivashina and Scharfstein 2010; in the European context, see Popov and Udell 2012), we show the importance of relationship lending in this transmission. Firms cannot fully offset a contraction in credit supply from their relationship banks by switching to other banks.

As a fourth contribution we document the effects of the 2007–2008 financial crisis on the real economy.[6] Data limitations made it difficult to show that shocks to financial markets transmit to the real economy.[7] In particular, micro data for many countries are only released with long time lags and usually contain either bank-level information on credit supply or borrower-level information on real outcomes. A number of papers use matched loan data.[8]

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[4] In a working paper, Jensen and Johannesen (2015) provide evidence on the effects of the financial crisis on consumer behavior and show that individuals respond to a tightening of credit by switching to banks that have not been exposed to the crisis.

[5] The financial crisis also renewed interest in the effects of monetary policy on banks' credit supply and credit risk-taking (see, e.g., Jiménez et al. 2012, 2014).

[6] This strand of research builds on earlier papers interested in how financial shocks to banks affect their borrowers. For example, Gan (1997) and Amiti and Weinstein (2011) exploit the bursting of the Japanese real estate bubble, Ongena et al. (2003) examine the Norwegian bank crisis, Schnabl (2012) looks at the 1998 Russian default, and Khwaja and Mian (2008) consider how unanticipated nuclear tests in Pakistan affect bank liquidity. Ashcraft (2005) shows that bank failures of healthy banks lead to a significant and permanent decline in real county income within Texas but is not able to study the effect at the firm level.

[7] There are several papers relating credit supply and the market evaluation of borrowers. For example, Slovin et al. (1993) and Baur (2012) find that financial crises lead to an increased co-movement of returns between financial sector stocks and the stocks of their borrowers, thereby providing indirect evidence that financial crises affect the real economy. A survey of chief financial officers in the United States, Europe, and Asia suggests that firms forewent profitable investment opportunities during the crisis as a result of binding external financial constraints (Campello et al. 2010), while Claessens et al. (2012) do not find evidence that the 2007–2008 financial crisis affected the investment levels of firms in advanced and emerging economies. Bricongne et al. (2012) examine the effect on international trade and find the overall impact of the financial crisis to be limited.

[8] Amiti and Weinstein (2013) exploit a large sample of matched bank–firm loan data for Japan for the 1990–2010 period. They trace loan movements back to bank, firm, industry, and common shocks, finding that bank supply shocks explain about 40% of aggregate loan and investment fluctuations. Acharya et al. (2014) investigate real effects of the sovereign debt crisis in Europe using a matched sample of loan and accounting information.

However, loan data and loan application data have the limitation that firms expecting not to obtain credit are discouraged from applying for credit and are thus missing in the data (Chodorow-Reich 2014), so this approach may ignore the most troubled firms. Chodorow-Reich (2014) addresses this problem by jointly observing employment outcomes of firms and the financial information of their banks and finds contractions in employment by firms that had precrisis banking relationships with less healthy lenders.

For lack of similar data on firms' bank relationships and capital stock, previous studies on the effects of the 2007–2008 financial crisis on investment resort to variation in firms' financial liquidity. In particular, they exploit *ex ante* variation in firms' long-term debt maturity (Almeida et al. 2012) and variation in firms' internal financial resources (Duchin et al. 2010) to document adverse effects of the 2007–2008 financial crisis on corporate investment. Our paper differs from these studies in three important dimensions: First, we exploit a database that contains both bank-related and firm-related information. Therefore, we can compare the investment behavior of firms that had borrowed from banks before the crisis that were similar except for their level of affectedness from the financial crisis. Our IV approach allows us to determine that the crisis was spread through the bank lending channel (the causal transmission of bank health to reduced firm borrowing and investment). This is a major advantage over prior literature in which it was difficult to separate the bank lending channel from the firm balance-sheet channel.[9] Second, we also observe unlisted, small and medium-sized firms. Prior investment studies (e.g., Lemmon and Roberts 2010) focus on large, public, firms that may find it easier to compensate for bank credit contraction by issuing bonds or stocks; in addition, the investment behavior of public firms may be distorted by short-termism (Asker et al. 2015). Third, we document that the U.S. financial crisis also caused real effects beyond the U.S. economy, in Germany.[10]

We thereby also speak to the literature on the effects of the globalization of banking on the international transmission of financial shocks (Peek and Rosengren 1997; Chava and Purnanandam 2011). Relatively little research exists on how financial crises in one specific country transmit to the corporate sector and the real economy in other countries (Peek and Rosengren 2000). Our study advances this literature by showing how a large shock to the U.S. financial markets affected real investment and employment in Germany.

[9] The latter is relevant when an economic downturn devalues assets in firms' balance sheets and thus their collateral and creditworthiness (see the discussion in Jiménez et al. 2012).

[10] Puri et al. (2011) examine the cross-border effects of the 2007–2008 U.S. financial crisis on retail bank lending in Germany. They show that savings banks that were indirectly affected by the U.S. financial crisis through their holdings in Federal State Banks (*Landesbanken*) with substantial subprime exposure rejected substantially more loan applications than unaffected banks.

Finally, this paper adds to the strand of literature that examines the cash flow sensitivity of investment of capital-constrained and capital-unconstrained firms (cf. Lamont 1997; Rauh 2006; Almeida and Campello 2007; Dell'Ariccia et al. 2008; Farre-Mensa and Ljungqvist forthcoming). We shed light on this question from a different angle by focusing on whether investment decisions are determined by loan supply shocks and by providing evidence on adjustment channels used to mitigate credit supply contractions by different types of firms.

We organize the rest of this paper as follows. Section 2 discusses relevant features of the financial system in Germany. Section 3 introduces our data, and Section 4 describes the empirical methodology we use. Section 5 presents our empirical results on the impact of credit supply by relationship banks on firm borrowing. Section 6 presents results on the real economy effects: firms' investment and employment decisions as well as heterogeneity in responses. Section 7 explores potential adjustment channels of firms. Section 8 offers some concluding remarks. Appendices A, B and C contain additional empirical results.

2 German banks, the U.S. financial crisis, and lending

Three features of the German financial system are central to our study: First, it is bank based rather than capital-market based and relationship lending is important. Second, many German banks engaged in proprietary trading activities and were affected by the U.S. financial crisis. Third, like in other countries, banking regulation puts limits on credit supply to bank customers on the basis of bank balance sheet indicators. In the following, we describe each of these three institutional features in greater detail.

2.1 The predominant role of bank financing and relationship lending

In Germany, domestic banking sector assets exceeded 300% of gross domestic product (GDP) before the financial crisis (compared with approximately 70% in the United States), thus demonstrating the importance of banks for the German economy. In contrast, equity markets have traditionally been less important for financing businesses: The ratio of stock market capitalization to GDP was only about one-third (45%) of that observed in the United States (130%) before the crisis.[11] The predominant role of bank financing is also reflected in firms' balance sheets: Bank loans account for 60% of total long-term corporate debt in Germany[12] (only 20% in the United States) and represent the lion's share of newly borrowed capital,

[11] See Deutsche Börse (2003).
[12] See Deutsche Bundesbank (2010), extrapolated results from financial statements of German enterprises from 1997 to 2009 (Table I).

while the issuance of corporate bonds plays a minor role (the share of bonds issued in newly borrowed capital is 10%[13] compared with 50% in the United States).

These differences in financing can be explained partly by the importance of small and medium-sized enterprises in Germany (the German *Mittelstand*). Access to financial markets for these firms is more limited due to their smaller size (Petersen and Rajan 1994; Harhoff and Körting 1998). Usual information asymmetries are aggravated between small and medium-sized firms and investors because these firms are (1) less likely to be monitored by rating agencies; (2) younger, thus having a shorter track record; and (3) subject to weaker disclosure requirements. All these factors increase the importance of sticky bank–borrower relationships as a way to mitigate information asymmetries (Diamond 1991; Hoshi et al. 1991; for an overview of the theoretical foundations, see Petersen and Rajan 1994). Therefore, German firms have traditionally maintained stable, long-term business relationships with one (or several) relationship bank(s) (*Hausbank*).[14] If bank–borrower relationships matter for the lending process, borrowers cannot easily switch banks when their relationship bank becomes liquidity constrained (Slovin et al. 1993). While banking relationships remain important during a financial crisis, sticky bank–borrower relationships make firms vulnerable if their particular relationship banks get into distress (Sette and Gobbi 2015).

2.2 German banks engaged in trading and were affected by the U.S. financial crisis

Most German banks are universal banks, i.e., they are active as both commercial and investment banks (in addition to providing insurance and other financial services). Universal banks in Germany account for 97% of all institutions and 75% of assets (Hüfner 2010). The combination of different banking activities under one roof makes the lending activities of German banks particularly susceptible to liquidity and equity shocks from investment activities.

The German banking system is highly fragmented. There are three kinds of banks ("three pillars"): public sector banks, local cooperative banks, and private banks. All these banks usually operate as universal banks and many of them engage in proprietary trading. Some specifics of public sector banks are important for our analysis. They include savings banks (owned by municipalities)[15] and Federal State Banks (*Landesbanken*, which are owned by the

[13] See Deutsche Börse (2001).

[14] Puri and Rocholl (2008) and Puri et al. (2013) provide evidence on the importance of retail banking relationships in Germany.

[15] Six (out of 431) savings banks are not owned by municipalities: Bordesholmer Sparkasse AG, Die Sparkasse Bremen AG, Hamburger Sparkasse AG, Sparkasse zu Lübeck AG, Sparkasse Mittelholstein AG, and Sparkasse Westholstein.

regional savings banks and by the federal state in which they are located).[16] Federal State Banks act as a central institution for the regional savings banks (e.g., financing infrastructure projects) and as main bank for the federal state in which they are located. Together, public banks accounted for approximately 40% of total assets before the crisis.[17]

The importance of the aforementioned roles as a public institution, however, has tapered off, and Federal State Banks have increasingly operated on an international scale (Puri et al. 2011). These business operations are backed up by the public founding entities, which have guaranteed that the bank can meet its financial obligations at all times (by providing liquidity support and capital injections if needed). Among several Federal State Banks, the guarantees have caused excessive risk taking and significant exposure to international financial risks.

German banks were severely hit at the onset of the U.S. financial crisis because they had invested heavily in structured credit products in the United States. Columns (2) and (3) in Table 1 show the investment of selected German banks in toxic conduit- and special investment vehicle–financed assets before the crisis. In total, the investment of German banks in toxic assets was estimated to be 230 billion euros (Hüfner 2010). These investments led to significant write-downs of several billions of euros in 2007 and 2008 (see column (4) of Table 1). According to Bloomberg[18], 7% of global write-downs on such assets between 2007 and 2009 can be attributed to German banks.[19]

The write-downs over the course of the U.S. financial crisis significantly burdened the result of banks' proprietary trading activities and caused massive problems for several German banks. As such, the U.S. financial crisis directly affected banks' financial scope for supplying credit to customers. Furthermore, several private banks and Federal State Banks needed to be rescued by owner or government interventions to prevent default. Because the affected Federal State Banks are partly owned by savings banks, which had to make guarantees or equity injections, the write-downs in the wake of the crisis also indirectly narrowed the financial scope for some of the savings banks.

In addition, firm lending also became less attractive to healthy banks due to potentially high returns from investment in fire sales. Anticipating a potential fire sale, banks with liquidity and with the ability to identify attractive trading opportunities thus had an incentive

[16] Savings banks also offer universal services but are limited in their regional lending activity to the municipality in which they are located ("regional principle"). Their legal mandate is not to maximize profits but rather to provide financial services to their region and to strengthen competition in the banking sector.
[17] World Bank Financial Regulation Database, values for 2005.
[18] Values from Bloomberg series WDCI.
[19] In 2010, German banks' portfolios still contained substantial amounts of structured products (total of more than 200 billion euros; Deutsche Bundesbank 2010).

to reduce credit supply on their part (Vishny and Shleifer 2010; Diamond and Rajan 2011; Abbassi et al. 2015).[20]

Table 1: Exposure of Selected German Banks to U.S. Structured Credit Products

	Ownership	Conduit- and special investment vehicle–financed assets before the crisis		Asset write-downs 2007-08
		… in % of capital	… in % of assets	… in bn. US$
	(1)	(2)	(3)	(4)
Sachsen LB	Public (Federal State Bank)	1126	30.3	2.5
WestLB	Public (Federal State Bank)	542	12.7	4.6
IKB Deutsche Industriebank AG	Private	494	20.5	14.8
Dresdner Bank AG	Private	364	9.9	3.9
Landesbank Berlin	Public (Federal State Bank)	179	2.2	unknown
Bayern LB	Public (Federal State Bank)	170	5.1	6.9
HSH Nordbank	Public (Federal State Bank)	126	4	3.5
Deutsche Bank AG	Private	114	3.3	10.4
HypoVereinsbank AG	Private	105	6.6	unknown
Nord LB	Public (Federal State Bank)	89	2.9	unknown
Commerzbank AG	Private	85	2.2	2.3
Helaba	Public (Federal State Bank)	68	1.1	unknown
DZ-Bank AG	Co-operative	61	1.3	2.6
LB Baden-Württemberg	Public (Federal State Bank)	59	1.7	4.7
KfW	Public	58	2.6	unknown

Notes: Comparability is limited by different dates and varying definitions.
Source: See Hüfner (2010), Table 1 (which is based on Fitch Ratings (2007), "ABCP Concerns Trigger Liquidity Issues for German Banks," Germany Special Report, August) and Onaran/Pierson, Bloomberg, September 29, 2008 (http://www.bloomberg.com/apps/news?pid=newsarchive&sid=aSlW.imTKzY8, last accessed on April 13, 2015).

2.3 Banking regulation sets limits to money creation and credit supply

The Eurosystem and banking regulation set certain limits on bank money creation and credit supply by banks. First, the European Central Bank (ECB) requires credit institutions to hold compulsory deposits on accounts with the national central banks.[21] Second, banking regulation requires a bank to hold a certain amount of equity capital for every credit risk or other risk it takes.[22] The regulations imply that banks suffering losses may not be able to

[20] For our IV strategy, we rely on a non-zero correlation of gains and losses from proprietary trading with credit supply to firms, but we do not require assumptions about the specific nature of this correlation.
[21] In the period of the current analysis, the minimum reserve requirement was 2% of the sight deposits that nonbanks hold at a bank. Thus, banks cannot lend more than 50 times the amount they hold as central bank money. To obtain central bank money in central bank credit operations, banks have to provide collateral. During the financial crisis, the ECB extended the range of assets it accepted as collateral several times to sustain liquidity in the financial market (European Central Bank 2013).
[22] According to the rules of the Basel I accord, which were in place through the end of 2006, credit lent to business customers had to be backed by 8% equity capital. Since 2007, according to the refined rules of the Basel II accord, the 8% equity capital requirement is weighted by the default risk of the credit (i.e., the creditworthiness of the customer). Subsequently, the financial crisis led to the development of stricter regulations. According to the "Basel 2.5" rules of 2009, certain securities have to be backed by more equity capital than before. Since 2014, after the period of this analysis, the Basel III accord requires banks to provide

provide further credit if their equity falls below the capital adequacy requirement. Even if the equity is still above the threshold, internal risk management may induce banks to restrict lending when losses occur because the smaller equity buffer implies a larger risk of falling below the threshold in the future. In the case of universal banks active in both proprietary trading and commercial banking, large losses from proprietary trading may thus spill over through the impact to the common equity base, resulting in a reduction of their commercial lending activity.[23]

3 Individual matched firm and bank panel data

3.1 Linking bank and firm data via individual bank relationships

Our database consists of financial statements of nonfinancial German firms linked with the financial statements of each firms' relationship bank(s). Both data sources are provided by Bureau van Dijk. Dafne, the financial statements database of nonfinancial firms, includes information for the 2004–2010 period, and since 2006, it covers more than 85% of all incorporated firms in Germany, the majority of which are unlisted.[24] Because small firms are not required to publish their income statements, sales and profit information are only available for a subsample.[25] Besides the unconsolidated balance sheet and income statements, the database includes further information such as the set of bank(s) a firm reports as its relationship bank(s). We observe the names and bank identification codes of the relationship banks but not the amount borrowed from them. All this information is updated regularly, usually at the end of the financial year.

Using the identification codes of the relationship banks, we merge unconsolidated financial statements of each relationship bank with each single firm. The bank financial statements stem from the Bankscope database of banks active in Germany from 2004 to

generally more equity capital and has also introduced new liquidity standards (for details on the Basel regulations, see, e.g., Blundell-Wignall and Atkinson 2010). The overall Tier 1 capital ratio must not fall below 4%.

[23] More than 99.9% of the firms and banks in our sample publish their financial statements according to the German Commercial Code (*HGB*). Because we use gains and losses from proprietary trading as reported in the income statement according to the German Commercial Code, these gains and losses affect regulatory capital. In contrast to the German Commercial Code, according to US-GAAP or IFRS, losses from the valuation of available for sale-securities would usually belong to Other Comprehensive Income (cf. Lachnit 2005).

[24] The coverage of financial statements of incorporated firms is very high due to strict publication requirements.

[25] According to Art. 267 of the German Commercial Code valid until 2008 (since 2009), small firms fulfill at least two of the following three conditions: (1) total assets do not exceed 4.015 (4.84) million euros, (2) sales do not exceed 8.03 (9.68) million euros, and/or (3) the number of employees is equal to or less than 50.

2010.[26] It includes balance sheets and income statements as well as information on ownership, affiliated companies, and branches. A comparison with the German Bank Statistics provided by the German Central Bank shows that Bankscope covers, on average, 83% of all banks in Germany over this period.[27]

3.2 Firm and bank characteristics and time trends

Firm characteristics. Table 2 shows descriptive statistics for the firms in our sample. The average firm has a balance sheet total (total assets) of 10.9 million euros, fixed assets of 2.2 million euros, and liabilities of 4.8 million euros.[28] The annual growth rates of fixed assets and liabilities are, on average, 1.1% and 0.6%, respectively, and exhibit substantial variation between and within firms. Based on the smaller sample of firms for which sales information is available, the average turnover amounts to 28 million euros, with an average annual growth of 1.8%.

The firms in our sample have, on average, 1.4 relationship banks. Almost half of the firms have at least one savings bank as a banking partner, 20% have a local cooperative bank, and 33% have one of the large private banks.

Of the firms in our sample, 1.7% establish an additional bank relationship in a given year, and about the same percentage terminate an existing bank partnership, such that the average change in the number of relationship banks is close to zero. Altogether, 3% of firms swap a relationship bank for another in any given year, keeping the number of relationship banks constant. Overall, these descriptive statistics suggest that firm–bank relationships are stable over time, presumably because establishing a new banking relationship is costly for firms, as it involves developing a reputation for nonopportunistic behavior to counteract informational asymmetries (Harhoff and Körting 1998).

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[26] The data also include subsidiaries of foreign banks but excludes branches of foreign banks. Fillat et al. (2015) shed light on the question how branches and subsidiaries differ in their response to regulation and in the diffusion of financial shocks.

[27] Our estimations focus on the period from 2006 to 2010. Because our regressions are based on first differences (see Section 4.1) and include lagged control variables in first differences, we exploit data from 2004 to 2010. Our raw sample of firms with at least three consecutive years of observations includes approximately 900,000 firm-year observations. We drop the smallest firms with total assets worth less than 10,000 euros (US$ 6960 on January 1, 2010) as well as firms in the real estate industry because these firms might be directly affected by the subprime market crisis in the United States. For 507,457 of the 699,104 firm-year observations left after applying this first sample restriction, we are able to match bank statements for all relationship banks at least from 2007 and onward. Our last sampling step concerns the availability of information on long-term lending by all relationship banks of a firm, which leaves us with 291,079 firm-year observations in the final sample. From the 1700 banks, on average, in Bankscope per year, almost 90% have a lending relationship with at least one firm covered in our final sample. For approximately 70% of the banks covered in Bankscope, we also observe information on long-term lending.

[28] For both the growth rates of fixed assets and liabilities, we exclude the bottom and top 1% from the sample to avoid a situation in which outliers drive the estimated coefficients. Regarding the number of employees, we only include firms with more than 5 employees in the analysis.

Table 2: Descriptive Statistics for Firms

	Mean	Std dev.	25% quantile	Median	75% quantile	Number of obs.
Dependent variables						
Liabilities in th. Euros	4797	155,648	101	280	896	291,079
Liabilities, growth rate	0.006	0.498	-0.209	-0.007	0.214	291,079
Fixed assets in th. Euros	2183	69,317	27	72	278	291,079
Fixed assets, growth rate	0.011	0.431	-0.223	-0.054	0.152	291,079
Number of employees	202	1695	22	63	145	36,843
Number of employees, growth rate	0,012	0.164	-0.014	0	0.048	36,843
Control variables						
Ratio of liabilities to total assets	0.540	0.299	0.281	0.543	0.805	291,079
Sales in th. Euros	28,370	502,955	700	1800	6000	88,153
Sales, growth rate	0.018	0.305	-0.010	0.000	0.070	88,153
Business tax rate	0.322	0.046	0.28	0.31	0.37	291,079
Change in business tax rate	-0.021	-0.007	0.000	0.000	0.038	291,079
Variables on relationship banks						
Number of relationship banks	1.404	0.684	1	1	2	291,079
Savings bank among relationship banks (yes=1)	0.481					291,079
Thereof: Savings bank affected by the crisis	0.149					291,079
Local cooperative bank among relationship banks (yes=1)	0.195					291,079
Other bank among relationship banks (yes=1)	0.570					291,079
Thereof: Large private bank	0.332					291,079
Avg. growth rate in credit supply from relationship banks	0.024	0.117	-0.016	0.017	0.056	291,079
Avg. growth rate in long-term credit supply from relationship banks	0.010	0.220	-0.031	0.005	0.047	291,079
Share of relationship banks with losses from proprietary trading	0.172	0.346	0	0	0	291,079
Gains and losses from proprietary trading to financial assets	-0.001	0.013	0	0	0	291,079
At least one additional bank relationship	0.017					158,760
At least one bank relationship less	0.017					158,760
Change in number of relationship banks	-0.002	0.224				158,760
Annual rate of substitution of a new relationship bank for an existing one	0.030	0.171				158,760
Additional variables						
Total assets in th. Euros	10,876	368,147	254	604	1789	291,079
Firm age in years	17	14	9	14	20	291,079
Ratio of tangible assets to total assets	0.291	0.234	0.103	0.222	0.428	291,079
Nominal capital in th. Euros	722	24,294	26	26	52	288,414
Nominal capital, growth rate	0.002	0.158	0	0	0	288,414
Cash in th. Euros	779	28,947	16	69	247	243,278
Cash, growth rate	0.033	0.888	-0.446	0.015	0.512	243,278
Dividends in th. Euros	291	12,130	0	0	0	220,830
Dividends, growth rate	0.016	1.759	0	0	0	220,830

Notes: The main sample, which covers firms for which all variables used in the main estimations are observed, includes 291,079 firm-year observations for 2006–2010. The additional variables are used for effect heterogeneity and the analysis of adjustment channels. Information on some of these variables is not available for all firms and years in the main sample, which leads to a smaller number of firm-year observations reported in the rightmost column. For the calculation of the growth rate of dividend payments, we added 1 before taking logs as otherwise only dividend paying firms would be in the sample. Further, the cash variables are only shown for firms with a growth rate of cash below the top and above the bottom 3% of the distribution. For dummy variables, only the mean and the number of observations are reported. "Large private bank" refers to Commerzbank, Deutsche Bank, Dresdner Bank, HypoVereinsbank/UniCredit, and Postbank (Dresdner Bank and Commerzbank merged in 2009).
Source: Authors' calculations are based on the firm financial accounts database Dafne, 2006–2010; growth rates also use 2005.

The average business tax rate amounts to 32%. It includes the corporate income tax rate, the mandatory so-called solidarity surcharge, and the local business tax rate. The rates of the latter depend on the location of the firm and differ across each of the more than 12,000 German municipalities as well as over time within individual jurisdictions. They range from a minimum tax rate of 9% to about 20%, with an average rate of approximately 16% (Fossen and Bach 2008).[29] The combined business tax rate has substantial time-series variation due to the corporate tax reform in 2008, which reduced the corporate income tax rate from 25% to 15% and also included changes in the local business tax.[30]

Bank characteristics. The descriptive statistics for the relationship banks of the firms included in our sample appear in Table 3. Germany's three-pillar system is reflected in the data: Of the relationship banks, 28% are saving banks, 29% are local cooperative banks, and the remaining 43% are other private banks. Due to a few very large private banks, the average of total assets is 5.8 billion euros, whereas the median is only 489 million euros. The average annual growth rate of credit and long-term credit supplied is 2.6% and 1.8%, respectively. The mean gains from proprietary trading are 165,000 euros. Only a quarter of banks engage in proprietary trading; conditional on trading, the mean gains are 659,000 euros.

U.S. financial crisis shows up in returns from proprietary trading. Figure 1 depicts the evolution of banks' gains and losses from proprietary trading scaled by financial assets (which do not include loans provided by the bank), conditional on proprietary trading activities. There is a clear dip for the median bank in 2008, which is even more pronounced at the first and third quartiles of the distribution. Figure 1 thus suggests that German banks with proprietary trading activities were indeed adversely affected by the U.S. financial crisis.

[29] We match the local business tax rates provided by the Federal Statistical Office using the postal codes of the firms.

[30] Further changes due to the corporate tax reform pertain to the generosity of depreciation allowances and special anti-avoidance provisions such as new thin capitalization rules (see, e.g., Buslei and Simmler 2012).

Table 3: Descriptive Statistics for Firms' Relationship Banks

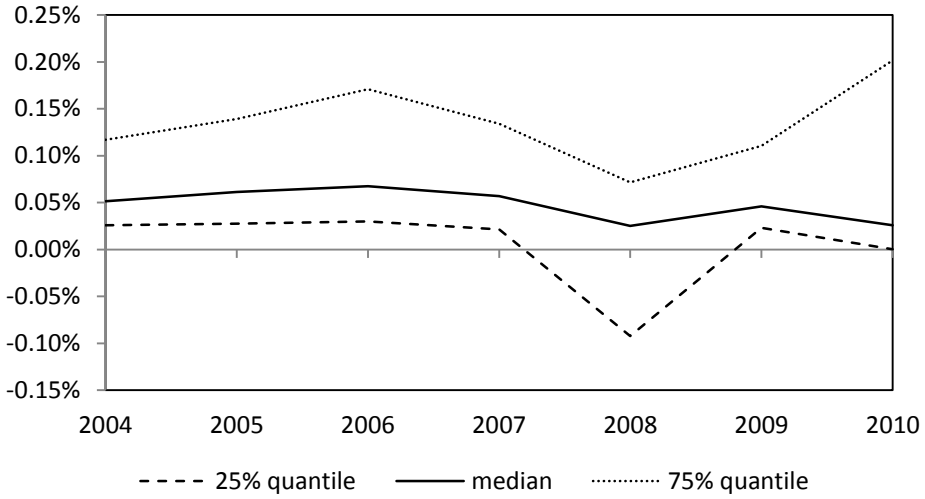
	Mean	Std dev.	25% quantile	Median	75% quantile	Numb. of obs.
Type of bank						
Savings bank	0.280					6640
Thereof: Savings bank affected by the crisis	0.119					6640
Local cooperative bank	0.292					6640
Other private bank	0.428					6640
Explanatory variables						
Total assets in th. euros	5,817,691	55,932,584	197,300	488,650	1,274,600	6640
Credit supply in th. euros	2,287,862	16,005,645	104,400	267,250	705,950	6640
Ratio of credit supply to total assets	0.567	0.144	0.491	0.582	0.658	6640
Credit supply, growth rate	0.026	0.080	-0.009	0.018	0.048	6623
Long-term credit supply in th. euros	979,880	4,746,310	59,300	154,500	412,100	6640
Ratio of long-term credit supply to total assets	0.339	0.109	0.283	0.350	0.410	6640
Long-term credit supply, growth rate	0.018	0.099	-0.024	0.010	0.050	5529
Instrumental variables						
Gains from proprietary trading in th. euros	165	149,350	0	0	0	6640
Gains from proprietary trading conditional on trading	659	298,498	100	100	400	1663
Additional variables						
Financial assets (w/o credit) in th. euros	1,438,360	13,002,858	17,100	78,450	249,050	6640
Ratio of other earning assets to total assets	0.386	0.144	0.293	0.371	0.464	6640
Ratio of deposits to total assets	0.876	0.081	0.863	0.895	0.916	6640
Tier 1 capital ratio	0.105	0.030	0.084	0.099	0.121	482
Ratio of equity to total assets	0.066	0.032	0.052	0.061	0.074	6640

Notes: The main sample includes 6640 bank-year observations. It includes all banks that were indicated as a relationship bank by at least one firm in the firm sample and for which information was provided on all variables used in the main estimations. Information on some of the variables reported here is not available for all banks and years in this sample, which leads to a smaller number of bank-year observations reported in the rightmost column. For dummy variables, only the mean and the number of observations are reported.
Source: Authors' calculations are based on the bank financial accounts database Bankscope, 2006–2010; growth rates also use 2005.

When a financial crisis is transmitted to the real economy through the bank lending channel, trading banks will contract their loan supply, compared with non-trading banks. This is because trading banks suffer losses from proprietary trading activities, or because of more attractive trading opportunities, which arise from looming fire sales. As Figure B1 in Appendix B shows, this is exactly what we observe once the U.S. financial crisis hit. Comparing banks with and without proprietary trading activities in 2005 and 2006 reveals that time trends in loan supply growth (indexed at 2006 = 1) are very similar for both groups before the crisis. However, after the financial crisis began in 2007, the credit amount lent by trading banks falls behind notably. The difference in credit supply between the two groups is even more pronounced when we consider the growth of long-term credit (see Figure B2 in Appendix B), in particular beginning in 2008 when the returns from proprietary trading

dipped (Figure 1). This evidence indicates that trading banks reduce their credit supply relative to other banks.

Figure 1: Distribution of Banks' Gains and Losses from Proprietary Trading over Time



Notes: Quartiles of nonzero gains and losses from proprietary trading activities of the banks in the sample, normalized by the bank's financial assets.
Source: Authors' calculations are based on the bank financial accounts database Bankscope, 2004–2010.

If relationship banking is important and firms cannot easily switch to other financing sources, the reduction in loan supply from some banks will transmit to their business customers and reduce real investment at the firm level. Figure B3 in Appendix B suggests that this happened in the aftermath of the U.S. financial crisis. It depicts the growth of fixed assets for the firms in our sample. We distinguish firms with only relationship banks engaging in proprietary trading activities, firms with only relationship banks not engaging in proprietary trading activities, or a mixture of both. Before 2008, the time trends appear similar. In 2009, firms whose relationship banks are all engaging in proprietary trading show a slower growth of fixed assets than firms whose relationship banks did not trade, though the difference is not that large. This suggests that real investment is impaired by lending relationships with trading banks. The small relative slowdown of investment compared with the larger relative decline in credit supply indicates that firms may partly compensate for the decline in credit supplied by using alternative financing. In the next section, we discuss the empirical methodology we use to explore the causal effect of bank lending on firm borrowing, investment, and employment, and to explore the adjustment channels firms may use to compensate for a contraction in loan supply.

4 Empirical methodology

4.1 The effect of credit supply on firm borrowing, real investment and employment

Our goal is to estimate the responses of firms to a contraction in loan supply by their relationship banks. We expect effects on financing, investment and possibly employment if capital markets are imperfect and information asymmetries between firms and investors exist. If firms cannot fully compensate for a contraction in their relationship banks' loan supply by borrowing from other banks, the overall amount borrowed by the firm will decrease. Further, if other sources of financing cannot fully substitute for the reduction in bank credit, firms will have to forego real investment opportunities, and possibly they will also reduce employment. To assess whether credit supply by relationship banks affects firm outcomes, we start out with the following model:

$$\log(y_{it}) = \beta_0 + \beta_1 \log(credit\ supply_{it}) + \beta_2 \log\left(credit\ supply_{i,t-1}\right) + \beta_3 t + \boldsymbol{\beta_4'}\, \boldsymbol{x_{it}} + \boldsymbol{\beta_5'}\, \boldsymbol{w_i} + \boldsymbol{\beta_6'}\, t\, \boldsymbol{w_i} + \delta_i + \theta_t + \varepsilon_{it} \quad (1)$$

where *i* indicates firms, *t* indicates years, and bold letters indicate vectors. In the main estimations, the outcome variable y_{it} is one of the following: i.) a firm's amount of liabilities;[31] ii.) a firm's stock of fixed assets (book values); or iii.) a firm's number of employees. We define the main explanatory variable *credit supply*$_{it}$ as the book value of all loans that a firm's relationship banks grant to their customers (excluding inter-bank credits). We also include the first time lag of *credit supply*$_{it}$ in the model to account for possible dynamic effects.

The coefficients β_1 and β_2 are of primary interest. If consistently estimated, they can be interpreted as elasticities, and β_1, $\beta_2 > 0$ imply that a reduction in the amount of credit supplied by a firm's relationship bank(s) reduces the firm's outcome variable y_{it}. The contemporaneous and lagged growth rates of *credit supply*$_{it}$ are endogenous, and we apply an IV approach to consistently estimate the coefficients, as we explain in the following subsection.

The vector of time-varying control variables $\boldsymbol{x_{it}}$ includes the tax rate on business profits and its first time lag to account for possibly dynamic effects of taxation on investment. As we mention in Section 3.2, there is substantial time-series and regional variation in the tax rate, which makes it a potentially important control variable. In robustness checks based on a subsample, $\boldsymbol{x_{it}}$ additionally includes a firm's total value of sales as a measure of firm size

[31] Our notion of liabilities does not include pension commitments, which play a minor role in Germany because of the statutory pension insurance system. It does contain non-interest bearing liabilities such as trade payables.

(income statements and thus sales are available for less than one-third of the firms in our main sample).

Time-invariant observable characteristics are collected in the vector $\boldsymbol{w_i}$. This vector includes the shares of two specific bank types in an individual firm's set of banking partners in 2006. Specifically, this is the share of savings banks that were financially affected by the crisis (due to the capital injections they needed to provide to their Federal State Banks) and the share of banks with U.S. affiliates. We discuss this further below when we introduce our instrumental variables. We control for linear time trends that may differ by the values of these time-invariant firm characteristics by including interactions of t and $\boldsymbol{w_i}$. Furthermore, we account for time effects θ_t that are common to all firms to pick up business cycle effects.

The model represented in eq. (1) includes observed and unobserved firm fixed effects $\boldsymbol{w_i}$ and δ_i, respectively. To avoid bias due to unobserved firm heterogeneity, we eliminate all time-invariant characteristics by first-differencing eq. (1). Using the common log approximation of a relative change, $\log(y_{it}) - \log(y_{i,t-1}) \approx \frac{\Delta y}{y_{i,t-1}}$, the equation in first differences is written as follows:

$$\frac{\Delta y_{it}}{y_{i,t-1}} = \beta_1 \frac{\Delta credit\ supply_{it}}{credit\ supply_{i,t-1}} + \beta_2 \frac{\Delta credit\ supply_{i,t-1}}{credit\ supply_{i,t-2}} + \beta_3 + \boldsymbol{\beta_4'}\, \Delta \boldsymbol{x_{it}} + \boldsymbol{\beta_6'}\, \boldsymbol{w_i} + \Delta\theta_t + \Delta\varepsilon_{it}. \quad (2)$$

The dependent variable is the one-year growth rate in y_{it}. In particular, if y_{it} is the capital stock, the dependent variable in eq. (2) is real net investment relative to the stock of fixed assets. The key explanatory variables are the current and lagged one-year growth rates in the credit volume that the firm's relationship banks lend to their customers. If a firm has more than one relationship bank, we take the average of the banks' growth rates.

One might argue that as long as one of the relationship banks is healthy, the firm should not be affected by the problems of the other banking partners; a healthy relationship bank could make up for any contraction in loan supply from the firm's other relationship banks. Therefore, in robustness checks, we use the *maximum* of the growth rates of credit supply from all banking partners instead of the average—that is, we consider a firm's best-performing bank only—and find very similar results (reported in Table C2 in Appendix C).

4.2 Endogeneity and IV approach

Endogeneity of credit supply. We apply a two-stage least squares (2SLS) IV approach because *credit supply*$_{it}$ and its time lag in the estimation eq. (2) are expected to be endogenous for four reasons. First, we measure the bank's loan volume, which is determined by supply *and* demand. Demand for credit, however, depends on a firm's investment opportunities,

which are likely reduced during the crisis. Thus, we would expect positive coefficients in an ordinary least squares regression even if there was no causal effect of credit supply, e.g., on the firms' capital stock. To isolate the supply effect from the demand effect, we require supply shifters as IVs, which are correlated with the bank's credit supply but are independent from credit demand.

Second, we do not observe the growth rate of the loans a bank grants to a specific firm but rather the growth rate of the bank's total loans supplied to all its customers. This corresponds to the growth rate of loans granted to a specific firm measured with error. The IV method econometrically accounts for measurement error.

Third, we aim to identify the bank lending channel—that is, the causal transmission from bank credit supply to reduced firm borrowing and investment—isolated from the firm balance sheet channel. The firm balance sheet channel describes reduced credit flow due to a devaluation of a firm's assets and, thus, of the collateral the firm can provide. Prior literature finds it difficult to separate the channels because bank distress and devaluation of firms' assets often occur simultaneously in an economic downturn. We thus require instruments that are related to the bank's credit supply and independent of the balance sheets of the firms.

Fourth, firms may change their relationship banks because they do not obtain the desired credit from their initial banking partners. This endogenously changes the explanatory variable of interest, namely, the credit supply of the current relationship banks. Therefore, we require instruments that are independent of changes in the firm-specific set of relationship banks.

Gains and losses from proprietary trading as IV. Our first excluded instrument is the amount of gains and losses from proprietary trading of the banks that the firm had a banking relationship with in 2006 (before the crisis), normalized by financial assets (excluding credit supplied).[32] We consider the average value of all banking partners if a firm has more than one relationship bank. We expect the two requirements for the validity of the IV to hold, relevance and exogeneity. First, the IV likely explains a bank's lending behavior (relevance): Banks suffering losses from proprietary trading experience a decline in their equity and are, consequently, likely to reduce lending (see Sections 2.3 and 3.2). We measure the strength of the IV in first-stage regressions, in which we empirically explore the relationship between proprietary trading gains and lending.

[32] To avoid endogeneity from firms changing their relationship banks, we fix the firm-specific set of relationship banks as observed in 2006 (before the U.S. financial crisis hit) for all subsequent years when we construct the IVs. Thus, changes in the set of banking partners do not affect the instruments. If the information on the relationship banks is missing for a firm in 2006, we use the information from 2007 instead.

Second, the assumption that a bank's gains and losses from proprietary trading are exogenous to the firm and can be excluded from the firm's borrowing, investment and employment equations, controlling for credit supply, is highly plausible (exogeneity assumption). Gains and losses from proprietary trading are independent of a bank's customers' business, by definition: Proprietary trading activities are defined as the financial trading activities that a bank conducts on its own account with the aim of generating profits and that are unrelated to business with its customers. Especially in the context of the unexpected and sudden financial crisis, a specific bank's losses from proprietary trading in securities in the U.S. are clearly unrelated to their specific German firm customers' business.

Nevertheless, exogeneity of this instrument could be compromised if the *changes* in a firm's outcome variables differed between firms with trading and nontrading relationship banks for reasons other than the change in credit supply. However, Appendix B shows that precrisis trends in overall credit (Figure B1) and long-term credit (Figure B2) were similar for the two types of banks, and investment trends by firm customers of the two types of banks were also similar before the crisis (Figure B3). This suggests that there is no systematic difference between the two types of banks from the perspective of the firm customers apart from the asymmetric shock to credit supply during the financial crisis that we exploit. Furthermore, descriptive statistics show that the industry compositions of the firm customers of trading and non-trading banks are similar.[33,34]

In summary, there is no reason to expect a bank's gains and losses from proprietary trading activities to directly influence firms' investment and employment decisions; we only expect an indirect effect through the bank lending and firm borrowing channel that we are explicitly modelling. Thus, proprietary trading gains of banks are exogenous from the viewpoint of individual firms, so the exclusion restriction required for the IV approach holds.

Affected savings banks as second IV. As a second excluded instrument, we adopt Puri et al.'s (2011) idea and exploit the notion that certain savings banks were affected by the

[33] On average, trading banks are larger than nontrading banks (see Table A1 in Appendix A). This is due to a small number of very large private banks among the trading banks. To assess whether certain types of firms select certain types of banking partners, we report firm characteristics by bank type in Table A2. Trading banks have larger firm customers on average, which is due to a selection of large firms to large banks. Apart from average firm size, however, firm characteristics across types of banking partners are very similar, for example, in terms of the industry composition. Moreover, not only large private banks, but also significant numbers of saving banks and local cooperative banks engage in proprietary trading (see Table A1). Also note that any differences in the *levels* of the outcome variables between customers of trading and nontrading banks leave our estimation results unaffected as they are controlled by first-differencing.

[34] Furthermore, the isolation of the bank lending channel from the firm balance sheet channel through our IV approach would fail if firms invested in similar financial assets as their relationship banks in their proprietary trading activities because shocks to a firm's value of assets would be correlated with its banks' trading losses. However, this is highly unlikely because structured credit market products such as collateralized debt obligations were predominantly held by banks, insurance companies, mutual funds, and investment trusts, not by firms.

financial crisis while other savings banks were not. The affected savings banks have substantial holdings in certain Federal State Banks, which had significant exposure to the U.S. subprime market and were deeply impacted by the financial crisis.[35] As discussed in Section 2.2, the affected savings banks had to make guarantees or equity injections into the distressed Federal State Banks, which reduced their willingness and ability to lend to business customers. Following Puri et al. (2011), we identify these savings banks by their location in the same federal state as the affected Federal State Banks. We compute the share of affected savings banks in a firm's set of relationship banks in 2006, before the crisis hit. Although we fix this variable to a precrisis year, the initial choice of relationship banks might be nonrandom, so we include this characteristic in the vector of time-invariant controls $\boldsymbol{w_i}$. The excluded IV is an interaction of this characteristic with a dummy variable indicating the period starting in 2007, when we expect the financial crisis to have affected the savings banks (cf. Puri et al. 2011). Thus, identification in the IV approach only exploits the changed lending behavior of the affected savings banks during the crisis.[36] This second IV adds information to the first IV because the indirect exposure of the savings banks to the financial crisis through their holdings in Federal States Banks does not appear in the gains and losses from their proprietary trading.

The availability of two excluded IVs for one endogenous explanatory variable allows us to test statistically whether the IV is valid under the assumption that the other IV is uncorrelated with the error term (overidentification test). The test is passed in all specifications, which suggests that the excluded instruments are indeed exogenous.

Robustness checks. Another candidate for an excluded IV is the share of banks in a firm's 2006 set of relationship banks that have subsidiaries or branches in the United States, where the financial crisis originated. These banks are likely to be exposed to the financial crisis through their U.S. affiliates. Again, we acknowledge the initial choice of such a bank as a relationship bank as potentially nonrandom and thus include their share in the vector of time-invariant controls $\boldsymbol{w_{it}}$ whenever we use the additional IV. The IV is an interaction of this share with a year dummy for 2008, the climax of the banking crisis in the United States (Lehman Brothers collapsed in fall 2008). Unfortunately, our bank data only provide information on affiliates for 2012; we assume that a bank's structure of affiliates in earlier years corresponds with that observed in 2012, which implies some measurement error.

[35] The affected Federal State Banks are Bayern LB, Sachsen LB (acquired by Landesbank Baden-Württemberg in 2008), and West LB (Puri et al. 2011).

[36] In robustness checks, we interact a firm's share of savings banks in 2006 affected by the financial crisis with a time dummy for 2008 only, when the affected savings banks were most strongly hit by the crisis.

Because of this data limitation, we use this third IV in additional robustness checks only. Another robustness check exploits membership to Eurex Exchange as an indicator for active presence in securities markets (cf. Abbassi et al. 2015). The overidentification test is still passed with the additional instruments, and the estimation results (reported in Appendix C.1) remain very similar.

5 Effect of relationship banks' credit supply on firm borrowing

Elasticity of firm liabilities. Table 4 reports the results from estimating eq. (2) when we use the amount of a firm's liabilities as the outcome y_{it}. In column (1), the coefficient β_1 of the contemporaneous credit supply from a firm's relationship banks is positive, but small and insignificant, whereas the coefficient of the first time lag β_2 is much larger and significant at the 1% level. This indicates that the credit supply of relationship banks indeed propagates to the liabilities of their business customers, but with a time lag.[37] Because we empirically detect this lag structure in column (1), in the following regressions, we omit the insignificant contemporaneous growth rate of credit supply and concentrate on β_2. Interpreting β_2 as the elasticity in eq. (1), we find that the elasticity of the firm's liabilities with respect to the credit supply of its banking partners in column (2) is 0.109 and significant at the 1% level. Thus, if a firm's relationship banks contract credit supply by 1%, this causes the firm's liabilities to decrease by about 0.1%. This indicates that firms' borrowing is affected by the lending policy of their relationship banks and that firms cannot fully substitute credit from other banks for credit from their relationship banks. As a robustness check we include lagged sales (in first differences) as an additional control variable (column (3)) and find our estimated elasticity virtually unchanged. Because sales are observed only in the subsample of firms that report income statements, the sample size drops significantly in this estimation (N = 88,153 instead of N = 291,079).

The results for bank lending and firm borrowing imply that firm–bank lending relationships are a relevant determinant of firms' access to external capital. We thereby contribute to a nascent literature on the role of relationship banking for the transmission of monetary shocks (Hachem 2011; Bolton et al. 2013) and to the scant empirical literature examining relationship banking (for the United States, cf. Petersen and Rajan 1994; for Germany, cf. Harhoff and Körting 1998).

[37] The time lag is probably due to the time lag between the date of negotiation and agreement about a bank loan and the date when the loan is actually paid out. While the bank loan appears on a bank's balance sheet immediately after agreement (loan commitment), it only shows up on the firm's balance sheet once the loan is paid out.

Table 4: Credit Supply from Relationship Banks Affects Firm Liabilities

2SLS regressions of firms' liability growth rates on credit supply growth rates of their banking partners

	(1)	(2)	(3)	(4)	(5)	(6)
Credit supply, growth rate (i)	0.029 (0.031)					
L.Credit supply, growth rate (ii)	**0.141*** (0.040)**	**0.109*** (0.035)**	**0.106** (0.048)**			
Long-term credit supply, growth rate (i)				0.069 (0.114)		
L.Long-term credit supply, growth rate (ii)				**0.389*** (0.103)**	**0.322*** (0.105)**	**0.303** (0.143)**
D.Business tax rate	0.222 (0.248)	0.202 (0.247)	0.746* (0.449)	0.243 (0.255)	0.206 (0.247)	0.726 (0.450)
L.D.Business tax rate	-0.048 (0.279)	-0.045 (0.278)	0.076 (0.398)	0.080 (0.284)	0.049 (0.285)	0.190 (0.411)
L.D.Sales			0.136*** (0.008)			0.137*** (0.008)
Share of savings banks affected by the crises	0.002 (0.003)	0.002 (0.003)	-0.002 (0.005)	0.002 (0.003)	0.002 (0.003)	-0.001 (0.005)
Year dummies	Yes	Yes	Yes	Yes	Yes	Yes
Constant	0.011*** (0.003)	0.013*** (0.003)	0.018*** (0.004)	0.015*** (0.003)	0.016*** (0.003)	0.020*** (0.004)
Number of observations	291,079	291,079	88,153	291,079	291,079	88,153
Shea's partial R^2 for (i)	0.08			0.01		
1st stage *F*-statistic for (i)	107.14			171.77		
Partial Shea's R^2 for (ii)	0.06	0.07	0.08	0.01	0.01	0.02
1st stage *F*-statistic for (ii)	233.68	333.81	376.00	309.04	185.53	277.48
Hansen test: *p*-value	0.40	0.89	0.22	0.51	0.62	0.17
Excluded instruments	IV set 1	IV set 2	IV set 2	IV set 1	IV set 2	IV set 2

Notes: For ease of exposition the coefficients of interest are in bold. Estimations are at the firm level. The dependent variable is the firm-specific growth rate in liabilities. The growth rates are log approximations. The growth rate of (long-term) credit supply and the share of savings banks affected by the financial crisis pertain to the firm's relationship bank(s). We link firms to their banking partners via information on individual firm–bank relationships. If a firm has multiple relationship banks, we calculate the mean of the (long-term) growth rates of their credit supply. D. indicates the first time difference of a variable, and L. indicates lagged values. Standard errors are robust to heteroscedasticity and reported in parentheses. ***/**/* indicate significance at the 1%/5%/10% levels. The (long-term) growth rate of credit supply and its first time lag (L.) are treated as endogenous. In the different specifications, we use alternative sets of excluded instruments:
IV set 1: Proprietary trading gains and the share of savings banks affected by the crisis in 2007 and onward among a firm's 2006 set of relationship banks. Contemporaneous and lagged variables.
IV set 2: Same as IV set 1, but with lagged variables only.
Robustness checks on the choice of instruments are provided in Table C1 of Appendix C.
Source: Authors' calculations are based on the firm financial accounts database Dafne and the bank financial accounts database Bankscope, 2006–2010; (lagged) first differences also use 2005 (2004).

Long-term credit supply. In columns (4) to (6) we repeat the estimations from columns (1) to (3) with long-term bank loans as the dependent variable. Long-term bank loans are defined as loans with a term of at least five years. Our results are qualitatively similar but the estimated elasticities are larger in size. The estimated elasticity of firm liabilities with respect to the amount of long-term credit supplied by relationship banks is 0.322 (column (5)). This is almost three times the size of the estimate we obtain for overall credit supply in column (2). Our results show that firm borrowing is, first and foremost, sensitive to the amount of long-

term credit that banking partners supply; short-term credit seems to be available more easily from other banks. Because real investment by firms relies primarily on long-term loans, these results already suggest that investment may react sensitively to the credit supply from relationship banks. We assess this directly in the following section. Before doing so, we briefly comment on the size of the estimated effect as well as on its validity and robustness.

Effect size. To shed further light on the size of the economic effect, we use a back-of-the-envelope calculation to quantify the impact of losses from proprietary trading during the U.S. financial crisis on firm borrowing. The average loss from proprietary trading of the banks in our sample between 2007 and 2008, normalized by financial assets, is -1.21 percentage points (from 0.069% down to -1.137%). Inserting this in the first-stage equation for long-term credit supply (Table A3 in Appendix A), we obtain $-0.0121 \times 0.832 = -0.01$. Thus, the financial crisis decreased the mean growth rate of long-term credit supply by one percentage point—in other words, more than half the mean growth rate in the sample of 1.8% (see Table 3). We insert this in the second-stage equation in column (5) of Table 4 and obtain $-0.01 \times 0.322 = -0.0032$. Thus, through losses from banks' proprietary trading, the financial crisis caused a decrease of the growth rate in firm liabilities by 0.32 percentage points, or 54% of the mean growth rate in liabilities, equal to 0.6% in the sample (cf. Table 2). We obtain a similar relative effect size of 55% when we repeat these calculations using total credit supply instead of long-term credit supply. The average reduction of the growth of firm borrowing by more than half indicates that the estimated effects are economically significant.

First-stage results. To assess the relevance of our instruments, we report first-stage results from the 2SLS estimations in Table A3 of the Appendix. Larger gains from proprietary trading increase the volume of credits, while banks that incur losses from trading activities due to the financial crisis reduce their lending volume. The predominant mechanism is thus the impact of the financial crisis on bank health, rather than investment opportunities in fire sales.[38] Our instruments are strong, as indicated by the first-stage statistics, which appear at the bottom of Table 4. The *F*-statistic of a test of exclusion of the two instruments from the first-stage estimation is well above 100 in all specifications. Because, in the case of two endogenous variables (columns (1) of Table 4), the first-stage *F*-statistic may not be sufficient to show the strength of the instruments, we also inspect Shea's partial R^2, which is sufficiently large. Furthermore, the null hypothesis of Hansen's overidentification test cannot be rejected

[38] The interaction of the variable "share of savings banks affected" with the dummy variable indicating the period of financial crisis, in and after 2007, has a negative and significant coefficient. This is consistent with reduced lending by savings banks in Germany that were affected by the U.S. financial crisis through their holdings of distressed Federal State Banks, after the onset of the financial crisis.

in any of the estimations (see *p*-values in Table 4). Thus, under the assumption of exogeneity of one excluded IV, the other excluded instruments are also exogenous.

Robustness checks. We subject our estimation results to several robustness checks, which are reported in Appendix C. Our results prove to be very robust to the choice of instruments, to specification choices, to the use of the maximal growth rate of credit supply instead of the average growth rate of credit supply, and to the exclusion of specific firms and banks (i.e., firms with financial institutions among their owners and subsidiaries of foreign banks or real estate banks).

We therefore conclude that relationship banking is important in Germany and that a firm's access to borrowed capital heavily depends on the credit supply of its banking partner(s)−in particular with respect to long-term loans with a term of at least five years. This opens up the possibility of bank loan supply affecting the real economy through firms' investment and employment decisions, which we study next.

6 Effects on the real economy: investment and employment

6.1 Investment

Table 5 presents our results from estimating the investment equation, i.e., eq. (2) when we use a firm's capital stock as y_{it}. Note that we employ the same set of instruments and explanatory variables as in the previous section, so the first-stage regression is identical. For a discussion of instrument relevance, refer to Section 5 and Table A3 in the Appendix.

In the previous section we found that bank loan supply matters for firm borrowing but with a time lag. Therefore we again use the lagged growth rate of credit supplied by a firm's relationship banks as the main explanatory variable. The estimated elasticity of a firm's stock of fixed assets with respect to the credit supplied by its banking partners is 0.073 and significant at the 1% level. Controlling for sales (in first differences) as a measure of firm size again reduces our sample size but leaves the point estimate of the elasticity of the stock of fixed assets unchanged (0.077, statistical significance at the 5% level, column (2)).

When we use long-term credit supply (column (3)) instead of total credit supply, we obtain much larger estimates for the elasticity of a firm's stock of fixed assets (point estimate of 0.211), in line with our finding for a firm's liabilities. This confirms that firm investment is much more sensitive to long-term credit supply from relationship banks than to their general credit supply, which is also what we would expect given that real investment relies primarily on long-term funds.

Table 5: Credit Supply Determines Firms' Real Investment and Employment

2SLS regressions of investment and employment growth rates on credit supply growth rates of their banking partners

Dependent variable	Fixed assets, growth rate			Employment, growth rate		
	(1)	(2)	(3)	(4)	(5)	(6)
L.Credit supply, growth rate	**0.073*** (0.027)**	**0.077** (0.038)**		**0.051** (0.025)**	**0.035 (0.029)**	
L.Long-term credit supply, growth rate			**0.211*** (0.081)**			**0.152** (0.074)**
D.Business tax rate	-0.371* (0.217)	-0.640* (0.377)	-0.368* (0.217)	-0.241 (0.256)	0.140 (0.372)	-0.261 (0.257)
L.D.Business tax rate	-0.586** (0.239)	-0.777** (0.343)	-0.527** (0.245)	0.173 (0.266)	0.362 (0.339)	0.229 (0.271)
L.D.Sales		0.116*** (0.006)			0.108*** (0.010)	
Share of savings banks affected by the crisis	0.005* (0.003)	0.011** (0.005)	0.004* (0.003)	0.010*** (0.003)	0.012** (0.006)	0.010*** (0.003)
Year dummies	Yes	Yes	Yes	Yes	Yes	Yes
Constant	-0.000 (0.003)	0.009** (0.004)	0.002 (0.002)	0.005 (0.003)	-0.004 (0.004)	0.008*** (0.002)
Number of observations	291,079	88,153	291,079	36,843	18,910	36,843
Shea's partial R^2	0.07	0.08	0.01	0.09	0.09	0.02
1st stage *F*-statistic	333.81	376.00	185.53	216.04	85.01	123.78
Hansen test: *p*-value	0.60	0.34	0.43	0.50	0.51	0.50
Excluded instruments	IV set 2	IV set 2	IV set 2	IV set 2	IV set 2	IV set 2

Notes: For ease of exposition the coefficients of interest are in bold. Estimations are at the firm level. The dependent variable is the firm-specific growth rate in fixed assets (columns (1) to (3)) and the growth rate in the number of employees (columns (4) to (6)), respectively. The growth rates are log approximations. The growth rate of (long-term) credit supply and the share of savings banks affected by the crisis pertain to the firm's relationship bank(s). We link firms to their banking partners via information on individual firm–bank relationships. If a firm has multiple relationship banks, we calculate the mean of the (long-term) growth rates of their credit supply. D. indicates the first time difference of a variable, and L. indicates lagged values. Standard errors are robust to heteroscedasticity and reported in parentheses. ***/**/* indicate significance at the 1%/5%/10% levels. The (long-term) growth rate of credit supply is treated as endogenous. We use the following set of excluded instruments:

IV set 2: Lagged proprietary trading gains and lagged share of savings banks affected by the crisis in 2007 and onward among a firm's 2006 set of relationship banks.

Robustness checks on the choice of instruments are provided in Table C1 of Appendix C.

Source: Authors' calculations are based on the firm financial accounts database Dafne and the bank financial accounts database Bankscope, 2006–2010; (lagged) first differences also use 2005 (2004).

Effect size. Our results show that the capital stock of firms shrinks if relationship banks reduce their credit supply. On average, a decrease in firms' external liabilities by one euro due to reduced credit supply from relationship banks leads to a reduction of 0.3 euros in the capital stock of firms.[39] In the following, we approximate the effect of bank losses from proprietary trading during the U.S. financial crisis on the net real investment rate of nonfinancial firms. In Section 5, we showed that the growth rate of long-term credit supply decreased by one percentage point due to these bank losses (based on the first-stage results).

[39] We obtain this result with the following calculation. Using the estimated elasticities and average values for liabilities and fixed assets from Table 2, a decrease in credit supply by 10% leads to a reduction in average firm liabilities by 0.0109 * 4,797,000 = 52,287 euros and a reduction in average firms' fixed assets by 0.0073 * 2,183,000 = 15,936 euros, which is 30% of the reduction in liabilities.

We insert this in the second-stage equation in column (3) of Table 5 and obtain -0.01 × 0.211 = -0.0021. This indicates that proprietary trading losses of relationship banks caused a decrease in the net real investment rate of their business clients by 0.21 percentage points or 19% of the mean net real investment rate in the sample of 1.1% (cf. Table 2). We obtain a similar estimate of 20% when we use total credit supply instead of long-term credit supply in the calculation. Thus, the economic effect of the financial crisis on real investment through distressed relationship banks is economically significant.

Robustness checks. We run several robustness checks to probe the robustness of our results concerning choice of instruments, of specification and of sample selection. The results are again reported in Appendix C. We find that the point estimates in the robustness checks are similar to our baseline estimates (both for overall credit supply and for long-term credit supply), which indicates that the results are robust.

6.2 Employment

Our finding that firms significantly reduce real investment when credit supply from their relationship banks decreases raises another question: Do firms also reduce employment as the second major input factor of production? This is what we expect if capital and labor are complements. To answer this question, we re-estimate eq. (2), but with the number of employees as y_{it}. The results are provided in Table 5, columns (4) to (6). We find a positive effect of credit supply on the number of employees in Germany, which is line with earlier findings for the U.S. (Chodorow-Reich 2014). The estimated elasticity in our baseline specification in column (4) is 0.051, significant at the 5% level. The coefficients in the employment equation are less precisely estimated because the sample, for which information on the number of employees is available, is considerably smaller than our baseline sample (N=36,843 instead of N=291,079), in particular when we additionally control for sales (N=18,910 column (5), point estimate: 0.035, p-value: 0.21).[40] Again we see that the coefficient of interest increases if long-term credit supply is used as an explanatory variable instead of overall credit supply (column (6)). Comparing the employment elasticity to the investment elasticity shows that employment is less elastic. This is a reasonable result for Germany, where subsidized short-time work agreements (*Kurzarbeit*) buffer employment in

[40] The coefficients we obtain from estimating the investment equation on this restricted sample are somewhat larger than the ones we report in Table 5, columns (1) to (3). The coefficient for Table 5, specification (1) estimated for the restricted sample is 0.171 (standard error: 0.051), significant at the 1% level. Full results are available upon request.

economic downturns (see Hijzen and Venn 2011) and where labor legislation puts tight restrictions on short-term firing policies.

Robustness checks. We run the same robustness checks as for investment and again find the point estimates to be statistically indistinguishable from our baseline estimates (both for overall credit supply and for long-term credit supply). The results are reported in Appendix C.

6.3 Effect heterogeneity

Next, we explore whether investment by certain types of firms is more or less sensitive to changes in credit supply from their relationship banks.[41] For example, smaller, younger firms may be more likely to suffer from information asymmetries in the capital market (e.g. Hadlock and Pierce 2010). Thus, for these firms it might be more difficult to obtain external credit. On the other hand, these firms are also more likely to accumulate financial slack because they anticipate experiencing financial constraints (Almeida et al. 2004).

In Table 6, columns (1) and (2), we follow prior literature on financial constraints (e.g., Almeida and Campello 2007) and split the sample by the ratio of fixed assets over total assets (tangibility). Firms with a higher share of tangible assets can provide more collateral and may find it easier to obtain loans from banks they did not have a lending relationship with in the past. Therefore, we expect investment of firms with higher tangibility to be less sensitive to changes in credit supply from their existing relationship banks. This is also what we find in the data: The elasticity is large and significant at the 1% level for firms with tangibility below the median (point estimate: 0.120, column (1)) but small and insignificant for those above the median (point estimate: 0.039, column (2)).[42]

Our large and comprehensive micro data base includes many small and medium-sized firms; while mean total assets are 10,876,000 euros, the first quartile stands at 254,000 euros only and the median at 604,000 euros (cf. Table 2). Small firms suffer more from information asymmetries in the capital market (because of weaker publication requirements, cf. Hadlock and Pierce 2010). If they are also less able to use alternative sources of financing, then we expect smaller firms to be more credit sensitive in their investment decision. Although this is what the relative sizes of our estimated coefficients suggest (columns (3) and (4)), the difference between the two point estimates is small and not statistically significant. The result

[41] Due to the relatively small size of our employment sample, we do not analyze heterogeneous effects with respect to employment.

[42] The differences in the investment sensitivity of firms with low and high tangibility are not driven by industry characteristics. If we only use firms in the manufacturing sector, results are unchanged but are less precisely estimated. Furthermore, results are unchanged when comparing firms with a share of tangible assets in the lowest third of the distribution to firms with a share of tangible assets in the highest third of the distribution. The same is true for firm size.

suggests that both firm types are able to compensate reductions in the credit supply to a similar extent.[43] This is in line with Farre-Mensa and Ljungqvist (forthcoming), who classify firms as financially constrained (or unconstrained) based on five measures commonly used in the literature, and who find that the firms classified as financially constrained do not behave as if they were constrained.

Table 6: Heterogeneous Effects by Firm Types

2SLS regressions of firms' fixed assets growth rates on loan growth rates of their banks

Sample split by	Tangibility		Firm size	
	Below median	Above median	Below median	Above median
	(1)	(2)	(3)	(4)
L.Credit supply, growth rate	**0.120*** **	**0.039**	**0.092** **	**0.067** **
	(0.039)	**(0.038)**	**(0.046)**	**(0.033)**
D.Business tax rate	-0.534	-0.533*	-0.467	-0.271
	(0.337)	(0.278)	(0.326)	(0.287)
L.D.Business tax rate	-0.726*	-0.562*	-0.280	-0.854***
	(0.386)	(0.290)	(0.366)	(0.310)
Share of savings banks affected	0.007*	0.001	0.002	0.012***
	(0.004)	(0.003)	(0.004)	(0.004)
Year dummies	Yes	Yes	Yes	Yes
Constant	0.014***	-0.015***	-0.001	-0.000
	(0.004)	(0.003)	(0.004)	(0.003)
Number of observations	145,510	145,929	144,554	146,525
Shea's partial R^2	0.08	0.06	0.06	0.08
1st stage *F*-statistic	415.23	128.86	135.83	423.74
Hansen test: *p*-value	0.79	0.72	0.80	0.92
Excluded IV	IV set 2	IV set 2	IV set 2	IV set 2

Notes: For ease of exposition the coefficients of interest are in bold. Estimations are at the firm level. The dependent variable is the firm-specific growth rate in fixed assets. The growth rates are log approximations. The growth rate of credit supply and the share of savings banks affected by the crisis pertain to the firm's relationship bank(s). We link firms to their banking partners via information on individual firm–bank relationships. If a firm has multiple relationship banks, we calculate the mean of the bank variables for each firm-year observation. D. indicates the first time difference of a variable, and L. indicates lagged values. "Above the median" is short for weakly above the median here. Standard errors are robust to heteroscedasticity and reported in parentheses. ***/**/* indicate significance at the 1%/5%/10% level. The growth rate of credit supply is treated as endogenous. We use the following set of excluded instruments:

IV set 2: Lagged proprietary trading gains and lagged share of savings banks affected by the crisis in 2007 and onward among a firm's 2006 set of relationship banks.

Source: Authors' calculations are based on the firm financial accounts database Dafne and the bank financial accounts database Bankscope, 2006–2010; (lagged) first differences also use 2005 (2004).

7 Adjustment channels

In the previous sections, we provide evidence that firm borrowing, investment and employment react significantly to changes in credit supplied by their relationship banks.

[43] A related dimension of heterogeneity is firm age. Information asymmetries are usually found to be more severe for younger firms (with less track record), which may therefore be more dependent on relationship banks. Splitting the sample at the median age of firms (14 years) or, alternatively, at age 6, indeed yields larger point estimates of the investment elasticity for younger firms than for older firms. But again the difference is small and not statistically significant (results available upon request).

Further, we find evidence for differences in the investment response of firm types to changes in credit supply by relationship banks, which suggests that firms are in the position to partly compensate a contraction in loan supply, and that the ability to do so varies between firms. In the following, we focus on two major adjustment channels: first, a change in banking partners, and second, substitution of external debt financing with self-financing by means of using accumulated cash holdings, reducing dividend payments, or issuing new equity.[44]

7.1 Change of banking partners

We start out by analyzing the role of new bank relationships. We do so by estimating eq. (2) with different dependent variables. In columns (1) and (2) of Table 7, we use a dummy variable as the dependent variable, which is one if a change in the set of banking partners occurs while the number of banking partners remains constant and zero otherwise.[45] We expect the likelihood of a change in the set of banking partners to be a function of the initial number of banking partners. We therefore include dummy variables to control for the number of banking partners in 2006, before the crisis (baseline category: one banking partner in 2006). The point estimate of interest of -0.024 (column (1)) indicates that the probability of switching a banking partner increases by 0.24 percentage points or 8 percent (evaluated at the baseline probability of 3 percent) when the growth rate of credit supply from the prior relationship banks decreases by 10 percent.

In columns (3) and (4), we use the change in the number of banking partners as the dependent variable. We again use dummy variables to control for the initial number of banking partners (in pre-crisis year 2006). Estimation results in column (3) show that the average number of banking partners significantly grows by 0.004 when prior relationship banks contract their lending by 10%. This is economically significant, given that the average change in banking partners is -0.002.

[44] Becker and Ivashina (2014) report that firms in the USA switch from loans to corporate bonds at times of depressed lending or poor bank performance. However, our data confirm that in Germany as a bank-based economy, issuing bonds is a negligible source of financing in the nonfinancial sector.

[45] In Table 7, as the key explanatory variable, we use the contemporaneous growth rate in the credit supply of the relationship banks instead of the first time lag because a new lending relationship is already established at the time of the credit negotiations.

Table 7: Change of Banking Partners

2SLS regressions

Dependent variable	Change of banking partners		Change in the number of banking partners	
	(1)	(2)	(3)	(4)
Credit supply, growth rate	**-0.024***		**-0.040****	
	(0.015)		**(0.016)**	
Share of banks with proprietary trading losses		**0.005***		**0.008****
		(0.003)		**(0.003)**
D.Business tax rate	-0.364***	-0.368***	-0.311**	-0.318**
	(0.103)	(0.104)	(0.126)	(0.126)
L.D.Business tax rate	-0.283***	-0.359***	0.223*	0.099
	(0.109)	(0.106)	(0.134)	(0.131)
Two banking partners in 2006	0.016***	0.016***	-0.028***	-0.028***
	(0.001)	(0.001)	(0.001)	(0.001)
Three banking partners in 2006	0.034***	0.034***	-0.073***	-0.074***
	(0.003)	(0.003)	(0.005)	(0.005)
Four banking partners in 2006	0.047***	0.046***	-0.160***	-0.161***
	(0.006)	(0.006)	(0.017)	(0.017)
Five banking partners in 2006	0.057***	0.056***	-0.350***	-0.351***
	(0.014)	(0.014)	(0.051)	(0.051)
Six banking partners in 2006	0.093***	0.092***	-0.522***	-0.522***
	(0.027)	(0.027)	(0.123)	(0.123)
Share of savings banks affected by the crisis	-0.010***	-0.009***	0.004***	0.006***
	(0.001)	(0.001)	(0.001)	(0.001)
Year dummies	Yes	Yes	Yes	Yes
Constant	0.037***	0.037***	-0.002	-0.002
	(0.001)	(0.001)	(0.002)	(0.002)
Number of observations	158,760	158,760	158,760	158,760
Shea's partial R^2	0.04	0.14	0.04	0.04
1st stage *F*-statistic	37.92	115.31	37.92	115.27
Hansen test: *p*-value	0.59	0.61	0.77	0.81
Excluded instruments	IV set 5	IV set 5	IV set 5	IV set 5

Notes: For ease of exposition the coefficients of interest are in bold. Estimations are at the firm level. "Change of banking partners" refers to a dummy variable which is one if a change in the set of banking partners occurs while the number of banking partners remains constant and zero otherwise. D. indicates the first time difference of a variable, and L. indicates lagged values. Standard errors are robust to heteroscedasticity and reported in parentheses. ***/**/* indicate significance at the 1%/5%/10% level. The growth rate of credit supply and the share of banking partners with proprietary trading losses are treated as endogenous. We use the following set of excluded instruments:
IV set 5: Proprietary trading gains and share of savings banks affected by the crisis in 2007 and onward among a firm's 2006 set of relationship banks.
Source: Authors' calculations are based on the firm financial accounts database Dafne and the bank financial accounts database Bankscope, 2006–2010; (lagged) first differences also use 2005 (2004).

We take a different approach in columns (2) and (4). Instead of the growth rate of credit supply from the relationship banks, we use the share of banks with losses from proprietary trading in a firm's current set of banking partners as the main explanatory variable of interest. This variable is a direct indicator of exposure of a firm to the financial crisis through its relationship banks. Because the current share of relationship banks with trading losses is endogenous due to potential changes in the set of relationship banks, we again run a 2SLS estimation. The excluded IV is the same as in the baseline specification and thus holds a firm's set of relationship banks in 2006 constant. We find that the higher the current share of

banking partners with trading losses, the more likely the firm is to adjust its set of banking partners (column (2)) and to increase its number of banking partners (column (4)). If all relationship banks of a firm incur proprietary trading losses, the probability of switching a relationship bank increases by 0.5 percentage points or 17 percent.

In summary, the results from columns (1)–(4) provide evidence that, on average, firms whose relationship banks were exposed to the U.S. financial crisis were able to partly balance a contraction in credit supply by changing their banking partners or by finding additional ones. While Abbassi et al. (2015) report that their findings for Germany indirectly "suggest that firms cannot compensate for the reduction in credit by trading banks with credit from other banks" (p. 5-6), we provide evidence that firms react by establishing new bank relationships.

However, we expect these average effects to hide considerable differences at the firm level since firms widely differ in their ability to open up new bank relationships. In Table 8, we break down the pooled effect and consider the following two dimensions: tangibility and firm size. We expect firms to more easily find new banking partners the higher their share of tangible assets to be pledged (e.g., Harris and Raviv 1990; Rajan and Zingales 1995). Columns (1) and (2) show the effects for firms with a share of tangible assets above and below the median, respectively. We find that the pooled effect in Table 7 (column (2)) is entirely driven by firms with a share of tangible assets above the median (point estimate: 0.012, significant at the 1% level). In the group of firms with low tangibility, by contrast, we do not find any evidence for their number of banking partners to change in response to banks' proprietary trading losses (point estimate: 0.003, *p*-value: 0.77).

In columns (3) to (5) we consider firm size. Due to stricter publication requirements for large firms (and thus smaller information asymmetries between firm and bank, cf. Harris and Raviv 1990; Rajan and Zingales 1995), we expect these firms to more easily establish new bank relationships than small firms. This implies that large (but not small) firms have the ability to increase their number of banking partners in order to compensate for a decline in credit supplied from long-standing banking partners. Again splitting the sample at the median, we find a point estimate for large firms of 0.009, which is similar to the pooled effect in Table 7 (column (2)), while the point estimate for small firms is very small (0.002, column (5)) and statistically insignificant (*p*-value: 0.65).[46] To assess whether the large-firm effect might in reality be a listed-firm effect we re-estimate the equation for large firms and

[46] Because of the comparably small sample that can be used for these estimations, standard errors are fairly large. Therefore, we cannot reject the hypothesis of zero difference between the two estimates.

include an interaction term between the share of affected banks (with proprietary trading losses) and a dummy variable indicating publicly listed firms. We see that publicly listed firms indeed have a larger probability of increasing the number of banking partners if needed. This might be part of the story why it is attractive for some firms to accept strict publication requirements and publication costs and become publicly listed. The baseline effect for large firms, however, does not decrease (column (4)) and is thus not driven by listed firms.

Table 8: Change in Number of Banking Partners Depends on Tangibility & Firm Size
2SLS regressions, dependent variable: change in no. of banking partners

Sample split by	Tangibility		Firm Size		
	Above median	Below median	Above median	Above median	Below median
	(1)	(2)	(3)	(4)	(5)
Share of banks with proprietary trading losses (i)	**0.012*** (0.004)**	**0.003 (0.004)**	**0.009* (0.005)**	**0.009* (0.005)**	**0.002 (0.003)**
Share of banks with prop. trading losses *x* indicator for publicly listed firms (ii)				0.122* (0.062)	
D.Business tax rate	-0.393** (0.182)	-0.270 (0.174)	-0.121 (0.216)	-0.134 (0.216)	-0.505*** (0.131)
L.D.Business tax rate	0.040 (0.192)	0.156 (0.178)	0.101 (0.230)	-0.071 (0.223)	0.296** (0.132)
Two banking partners in 2006	-0.028*** (0.002)	-0.028*** (0.002)	-0.029*** (0.002)	-0.030*** (0.002)	-0.031*** (0.002)
Three banking partners in 2006	-0.078*** (0.007)	-0.070*** (0.006)	-0.078*** (0.005)	-0.078*** (0.005)	-0.075*** (0.009)
Four banking partners in 2006	-0.158*** (0.024)	-0.164*** (0.024)	-0.166*** (0.018)	-0.167*** (0.018)	-0.152*** (0.056)
Five banking partners in 2006	-0.341*** (0.067)	-0.363*** (0.079)	-0.346*** (0.052)	-0.350*** (0.052)	-0.709** (0.318)
Six banking partners in 2006	-0.643*** (0.170)	-0.294** (0.144)	-0.527*** (0.122)	-0.529*** (0.122)	. .
Share of savings banks affected by the crisis	0.007*** (0.002)	0.004** (0.002)	0.008*** (0.003)	0.008*** (0.003)	0.005*** (0.001)
Year dummies	Yes	Yes	Yes	Yes	Yes
Constant	-0.001 (0.003)	-0.002 (0.003)	-0.009 (0.003)	-0.009 (0.003)	0.008 (0.002)
Number of observations	79,779	78,891	79,713	79,713	79,047
Shea's partial R^2 for (i)	0.14	0.13	0.14	0.14	0.13
1st stage *F*-statistic for (i)	36.26	304.47	65.70	69.63	698.05
Shea's partial R^2 for (ii)				0.03	
1st stage *F*-statistic for (ii)				54.87	
Hansen test: *p*-value	0.51	0.12	0.23	0.23	0.49
Excluded instruments	IV set 5	IV set 5	IV set 5	IV set 6	IV set 5

Notes: For ease of exposition the coefficients of interest are in bold. Estimations are at the firm level. D. indicates the first time difference of a variable, and L. indicates lagged values. Standard errors are robust to heteroscedasticity and reported in parentheses. ***/**/* indicate significance at the 1%/5%/10% level. The share of banking partners with proprietary trading losses is treated as endogenous. In the different specifications, we use the following sets of excluded instruments:
IV set 5: Proprietary trading gains and share of savings banks affected by the crisis in 2007 and onward among a firm's 2006 set of relationship banks.
IV set 6: Same as IV set 5, additionally including the interaction term between the indicator for publicly listed firms and the proprietary trading gains among a firm's 2006 set of relationship banks.
Source: Authors' calculations are based on the firm financial accounts database Dafne and the bank financial accounts database Bankscope, 2006–2010; (lagged) first differences also use 2005 (2004).

Robustness checks. As a robustness check we re-estimate the estimations from Table 8 with the change in credit supply as the main explanatory variable instead of the share of banks with proprietary trading losses (again using 2SLS regressions). Qualitatively, the results are the same and are reported in Table C3 in Appendix C.

In a nutshell, we observe pronounced heterogeneity in the likelihood of firms to change their number of banking partners. In particular, large firms and firms with a large share of tangible assets respond to contractions in loan supply by establishing new bank relationships.

7.2 Substitution of external debt with other sources of financing

Besides establishing new bank relationships to obtain external debt from a different outside creditor, firms can substitute external debt with other sources of financing. Essentially, there are three alternatives to debt financing: using funds initially designated for dividend payments, issuing new equity, or using free, accumulated cash. In the following, we exploit an important feature of our data set: that we can observe all of these balance sheet variables for most of the firms in our sample. If firms substitute external debt with funds from these alternative sources of financing, this substitution should be causally affected by credit supply by relationship banks. We therefore re-estimate eq. (2) with dividend payments, nominal capital, and cash, respectively, as outcome variables y_{it}.

Table 9 presents the results. We start with assessing the impact of credit supply on firms' dividend payments. Parts of the literature use dividend payments as an indicator of financially unconstrained firms. The underlying argument is that these firms can easily increase their internal funds by cutting dividends. Our results provide support for this rational. Column (1) shows that credit supply has a positive, causal effect on dividend payments (point estimate: 0.396, significant at the 5% level). In the context of the present paper this implies that a 10% reduction in credit supply by a firm's relationship bank(s) leads to a cut in dividends of about 4%. Next, we consider issuance of new equity as measured by the growth rate in nominal capital. On average, credit supply has a negative impact on nominal capital (column (2)). Firms thus compensate for part of the contraction in loans supplied by their banking partners by issuing new equity.

Table 9: Adjustment Channels of Firms

2SLS regressions

Dependent variable	Dividends, growth rate	Nominal capital, growth rate				Cash, growth rate			
	Full sample	Full sample	Without dividend payments			Full sample	Without dividend payments		
				Tangibility < median	Firm size < median			Tangibility < median	Firm size < median
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
L.Credit supply, growth rate	**0.396** **(0.158)**	**-0.019*** **(0.011)**	**-0.028**** **(0.013)**	**-0.035**** **(0.017)**	**-0.006** **(0.011)**	**0.159**** **(0.071)**	**0.186**** **(0.084)**	**0.057** **(0.097)**	**0.355**** **(0.142)**
D.Business tax rate	1.034 (1.013)	0.103 (0.084)	0.131 (0.093)	0.152 (0.151)	-0.055 (0.084)	-0.271 (0.479)	-0.366 (0.544)	-1.262 (0.778)	0.894 (0.741)
L.D.Business tax rate	-0.314 (1.159)	0.017 (0.109)	-0.023 (0.126)	0.001 (0.166)	0.245** (0.103)	-1.355** (0.555)	-1.052* (0.635)	-2.043** (0.897)	-1.955** (0.885)
Share of savings banks affected by the crisis	0.010 (0.010)	-0.002*** (0.001)	-0.002* (0.001)	-0.004*** (0.001)	-0.002** (0.001)	0.001 (0.006)	0.005 (0.006)	0.001 (0.009)	0.002 (0.008)
Year dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Constant	0.057*** (0.014)	-0.015*** (0.001)	-0.015*** (0.001)	-0.015*** (0.002)	-0.026*** (0.001)	0.033*** (0.006)	0.030*** (0.007)	0.031*** (0.009)	0.031*** (0.011)
Number of obs.	220,830	288,414	232,311	113,881	126,288	243,278	192,776	95,971	101,738
Shea's partial R^2	0.07	0.07	0.07	0.08	0.06	0.07	0.06	0.08	0.05
1st stage *F*-statistic	240.79	329.47	246.83	313.80	116.54	281.64	211.42	277.60	105.87
Hansen test: *p*-value	0.37	0.32	0.23	0.38	0.06	0.99	0.65	0.27	0.90
Excluded IVs	IV set 2	IV set 2	IV set 2	IV set 2	IV set 2	IV set 2	IV set 2	IV set 2	IV set 2

Notes: For ease of exposition the coefficients of interest are in bold. Estimations are at the firm level. The growth rate of credit supply and the share of savings banks affected by the crisis pertain to the firm's relationship bank(s). We link firms to their banking partners via information on individual firm–bank relationships. If a firm has multiple relationship banks, we calculate the mean of the bank variables for each firm-year observation. D. indicates the first time difference of a variable, and L. indicates lagged values. Standard errors are robust to heteroscedasticity and reported in parentheses. ***/**/* indicate significance at the 1%/5%/10% level. The number of observations is smaller in some columns because of missing data and because the dependent variables are zero (before taking logs) for some firm-year observations. For the calculation of the growth rate in dividends, we added 1 before taking logs as otherwise only dividend paying firms would be in our sample. In specifications (6) to (9), we exclude firms with a growth rate of cash in the top and bottom 3% of the distribution. Although the point estimates are not affected by the censoring, the estimates are more precisely estimated. The growth rate of credit supply and the share of banking partners with proprietary trading losses are treated as endogenous. We use the following set of excluded instruments:

IV set 2: Lagged proprietary trading gains and lagged share of savings banks affected by the crisis in 2007 and onward among a firm's 2006 set of relationship banks.

Source: Authors' calculations are based on the firm financial accounts database Dafne and the bank financial accounts database Bankscope, 2006–2010; (lagged) first differences also use 2005 (2004).

The pecking order theory suggests that new equity is the most expensive source of financing. We therefore expect firms able to compensate a reduction in credit supply by using other (less costly) sources of funds to be less likely to issue new equity, compared to those that cannot resort to other sources. Column (3) provides evidence for this presumption. We find a stronger reaction of nominal capital for the subsample of firms which are unable to increase internal funds by cutting dividends because they do not pay out any (we use dividend payment in 2007 as the splitting criterion). Among these firms, those with low asset tangibility even more resort to external equity, because their lack of collateral makes it hard to obtain credit from new banking partners (column (4)). Furthermore, smaller non-dividend-paying firms are less likely to issue new equity than larger ones (column (5)). This finding is in line with the argument that large firms have better access to the equity market.

Last, we test whether firms use accumulated cash to mitigate a reduction in credit supply. For this analysis we use the growth rate of cash (held in the form of liquid bank deposits)[47] as dependent variable. As shown by Almeida et al. (2004) and Hadlock and Pierce (2010), firms that are financially constrained are more likely to accumulate cash in high cash flow times. We expect these firms to use the accumulated cash to mitigate the reduction in credit supply. The average elasticity of cash with respect to the credit supply from the relationship banks is 0.159 (significant at the 10% level, column (6)).

Column (7) shows that accumulated cash of firms which do not pay dividends reacts more sensitively to a change in credit supply, in line with our expectations. Among these firms, we assess differences with respect to the tangibility of a firm's assets (column (8)). Our estimations suggest that firms with low asset tangibility are less likely to use accumulated cash to mitigate shocks to the firms' credit supply than the average non-dividend-paying firm. This result is consistent with our previous finding that firms with asset tangibility below the median exhibit high investment sensitivity with respect to bank loan supply (see Table 6, column (1)), while firms with high tangibility show little investment sensitivity (see Table 6, column (2)). However, this result raises the question why firms with low asset tangibility do not use accumulated cash to mitigate reductions in credit supply−in particular as these firms should be more likely to hold cash for precautionary saving motives (Almeida et al. 2004). Uncertainty about future credit supply could be a potential explanation: If such financially constrained firms expect the change in credit supply to be more permanent, they probably are reluctant to quickly use up their cash reserves. In column (9) we focus on small non-dividend-

[47] We do not include marketable securities because their value might have been affected by the financial crisis.

paying firms. The point estimate increases to 0.355 (significant at the 5% level). Our results thus show that both large *and* small firms are able to partly mitigate a contraction in credit supply but differ in the way of doing so: Large firms cut dividends (as they are more likely to pay out dividends), establish new bank relationships, and issue new equity; small firms resort to cash accumulated for this purpose.

We gauge the relative importance of the different adjustment channels for firms in our sample by calculating the average funds obtained from each channel. When relationship banks reduce their credit supply by 10%, firms decrease their cash holdings, on average, by 12,386 euros (0.1 × 0.159 × 779,000 euros; cf. Table 9 and Table 2), they reduce their dividend payments by 11,524 euros (0.1 × 0.396 × 291,000), and they externally raise new equity amounting to 1372 euros (0.1 × 0.019 × 722,000). In total, the additional self-financing amounts to 25,282 euros on average. In comparison, liabilities are reduced by 52,287 euros on average (0.1 × 0.109 × 4,797,000). Thus, firms are able to mitigate 48% of the reduction in debt financing through additional self-financing—more specifically, by using (accumulated) cash (49%), reducing dividends (46%), and issuing new equity (5%).[48]

8 Conclusion

This paper contributes to the literature on the transmission of financial shocks to the real economy and, more specifically, to the international propagation of financial crises through globalized banking. We explore these issues by exploiting a unique database in which we can observe a firm's borrowing, investment and labor employment decisions together with information on its relationship banks. The database contains financial statements of individual firms and their relationship banks in Germany over the 2004–2010 period. It includes small and medium-sized firms, which might be hit hardest by a contraction in loan supply. Our analysis exploits exogenous variation in the individual exposure of banks in Germany to the 2007–2008 U.S. financial crisis.

We find that banks in Germany that were affected by the U.S. financial crisis reduced their loan supply and thus internationally propagated the crisis. German firms whose relationship banks became distressed during the crisis (and thus contracted their credit supply) reduced overall borrowing. This indicates that relationship banking is important because firms cannot easily substitute loans from a relationship bank with loans from other banks.

[48] The calculation assumes that the average values of dividends, cash holdings and new equity, which we only observe in subsamples, are representative.

Furthermore, these firms significantly reduced their real investment and labor employment, which suggests that other sources of financing cannot fully make up for the reduction in credit supply. Overall, the mean net real investment rate of nonfinancial firms in Germany was reduced by one-fifth in 2008 due to losses from proprietary trading that their relationship banks suffered during the financial crisis.

For the first time we identify how firms mitigate a causal contraction in loan supply based on comprehensive micro data from a developed country. We document that firms with more tangible assets are less dependent on their relationship banks and establish new bank relationships if needed. This is consistent with the view that these firms can provide more collateral and can, therefore, borrow from other banks more easily. We further show that the average firm in our sample can offset almost half of a contraction in credit supply by using internal funds, by reducing dividend payments, and by issuing new equity (to a smaller extent).

Overall, our results show the importance of relationship lending and point to the risks of globalization of banking in the international transmission of monetary shocks. This is a timely insight given the current debate on banking regulation. One implication of our results is that a separation of investment banking from commercial banking could reduce the contagion risk from a financial crisis to a crisis of the real economy. The transmission channel analyzed here would be disrupted: Losses from proprietary trading would not reduce the common equity base of a universal bank and would not impede the ability of commercial banks to lend to nonfinancial firms. These considerations lend support to banking separation initiatives, such as the Volcker Rule in the United States and the Liikanen Report in the European Union. On the other hand, one can argue that universal banking facilitates the diversification of risks in other economic situations.

For the economic modeling and policy management of crises, our results document the importance of the bank lending and firm borrowing channel in the development of a real economic crisis. Distress on the side of banks causally spills over to real investment and labor employment of nonfinancial firms. This implies that monetary and fiscal policy should aim to maintain credit supply during a crisis.

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Appendix A: Supplementary tables

Table A1: Bank Characteristics by Bank Type

	Trading vs. nontrading banks		Type of bank		
	Nontrading banks	Trading banks	Savings bank	Local cooper. banks	Other banks
Explanatory variables					
Total assets in th. euros	1,236,556	19,528,038	2,286,046	563,498	11,723,731
Credit supply in th. euros	707,082	7,018,795	1,360,294	327,167	4,236,078
Credit supply / total assets	0.571	0.554	0.578	0.580	0.552
Long-term credit supply in th. euros	393,176	2,735,758	867,179	200,233	1,586,756
Long-term credit supply/total assets	0.339	0.337	0.368	0.353	0.310
Other earning assets over total assets	0.380	0.402	0.380	0.371	0.400
Share deposits to total assets	0.881	0.860	0.891	0.877	0.865
Instrumental variables					
Gains from proprietary trading	15	614	221	17	229
Type of bank					
Savings bank	0.163	0.631	1	0	0
Local cooperative bank	0.350	0.120	0	1	0
Other bank	0.487	0.249	0	0	1
Bank-year observations	4977	1663	1860	1941	2839

Notes: The table shows mean bank characteristics by bank type. Banks are defined as trading banks if they have nonzero gains or losses from proprietary trading in 2005 and 2006.
Source: Authors' calculations are based on the bank financial accounts database Bankscope, 2006–2010; growth rates also use 2005.

Table A2: Firm Characteristics by Type of Relationship Banks

	Trading vs. nontrading banks			Type of banking partner		
	Non-trading banks only	Trading and non-trading banks	Trading banks only	Savings banks	Local coope-rative banks	Other private banks
Dependent variables						
Total assets in th. euros	3912	18,769	11,863	4387	2515	17,700
Capital stock in th. euros	867	4163	2220	1459	719	3296
Capital stock, growth rate	0.010	0.023	0.007	0.015	0.018	0.012
Total liabilities in th. euros	1797	7664	5387	1948	1146	7728
Ratio of liabilities to total assets	0.547	0.538	0.537	0.552	0.560	0.527
Liabilities, growth rate	0.002	0.007	0.008	0.007	0.007	0.006
Variables on relationship banks						
Number of banking partners	1.136	2.335	1.249	1.557	1.676	1.603
Savings bank	0.290	0.630	0.528	1.000	0.339	0.259
Local cooperative bank	0.327	0.395	0.069	0.138	1.000	0.085
Other private bank	0.489	0.783	0.545	0.308	0.248	1.000
Industries						
Agriculture, forestry	0.019	0.008	0.008	0.009	0.016	0.011
Mining and quarrying	0.001	0.001	0.001	0.001	0.001	0.001
Manufacturing	0.181	0.254	0.180	0.199	0.208	0.206
Energy and water supply	0.006	0.009	0.006	0.007	0.005	0.008
Construction	0.181	0.175	0.127	0.178	0.213	0.120
Wholesale and retail trade	0.230	0.252	0.222	0.231	0.252	0.228
Hotels and restaurants	0.027	0.013	0.032	0.027	0.022	0.023
Transport, storage and communic.	0.054	0.047	0.051	0.050	0.050	0.051
Financial intermediation	0.013	0.011	0.015	0.010	0.009	0.016
Renting and business activities	0.208	0.176	0.264	0.200	0.164	0.259
Public administration and defense	0.012	0.007	0.013	0.011	0.008	0.011
Education	0.024	0.016	0.027	0.028	0.015	0.023
Health and social work	0.046	0.031	0.054	0.049	0.037	0.044
Firm-year observations	79,373	49,784	161,922	139,933	56,787	165,934

Notes: The table shows firms' average characteristics by type of their banking partners. In the calculation of the means by the type of banking partner, all firms with at least one banking partner of the respective type are used. Because firms might have several banking partners, the sum of the observations over the three rightmost columns does not equal the number of firms in the sample.

Source: Authors' calculations are based on the firm financial accounts database Dafne and the bank financial accounts database Bankscope, 2006–2010; growth rates also use 2005.

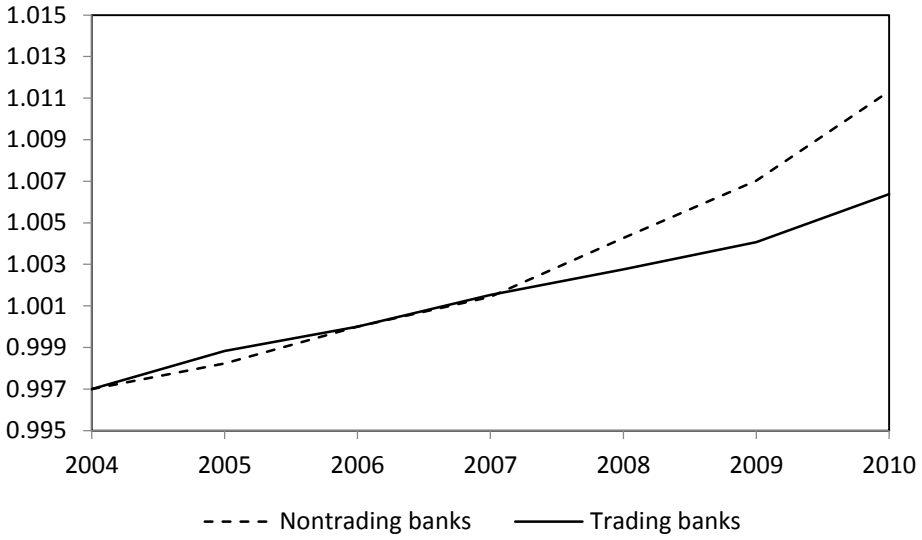
Table A3: First-Stage Results

Dependent variable:	Lagged credit supply, growth rate	Lagged long-term credit supply, growth rate
	(1)	(2)
Lagged gains from proprietary trading over financial assets	**2.527*** **	**0.832*** **
	(0.144)	**(0.066)**
Share of savings banks affected *x* time dummy in and after 2007	**-0.024*** **	**-0.015*** **
	(0.001)	**(0.001)**
Share of savings banks affected by the crisis	0.001***	0.007***
	(0.000)	(0.001)
D.Business tax rate	0.175***	0.055
	(0.051)	(0.041)
L.D.Business tax rate	-0.604***	-0.491***
	(0.073)	(0.053)
Year dummies	Yes	Yes
Constant	0.020***	0.018***
	(0.001)	(0.001)
Number of observations	291,079	291,079

Notes: For ease of exposition the coefficients of interest are in bold. The table shows the first-stage results for the second-stage IV regressions in Table 4 and Table 5. The first column is the first stage when overall credit supply is the endogenous explanatory variable, and the second column when long-term credit supply is considered instead. In the 2SLS estimation, the first stage is identical regardless of the dependent variable in the second stage. The growth rates are log approximations. D. indicates the first time difference of a variable, and L. indicates lagged values. Standard errors are robust to heteroskedasticity and reported in parentheses. ***/**/* indicate significance at the 1%/5%/10% level.
Source: Authors' calculations are based on the firm financial accounts database Dafne and the bank financial accounts database Bankscope, 2006–2010; (lagged) first differences also use 2005 (2004).

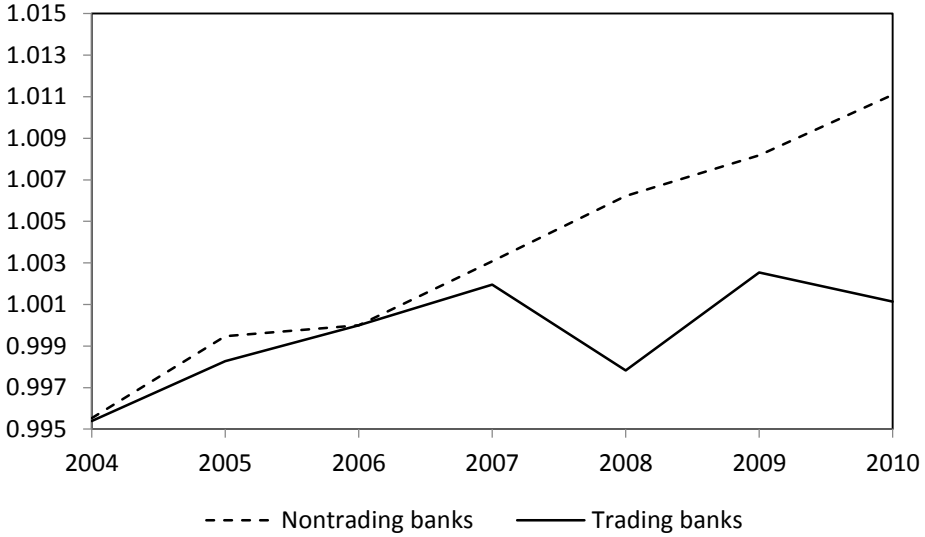
Appendix B: Supplementary figures

Figure B1: Growth of Credit Supply from Trading and Nontrading Banks



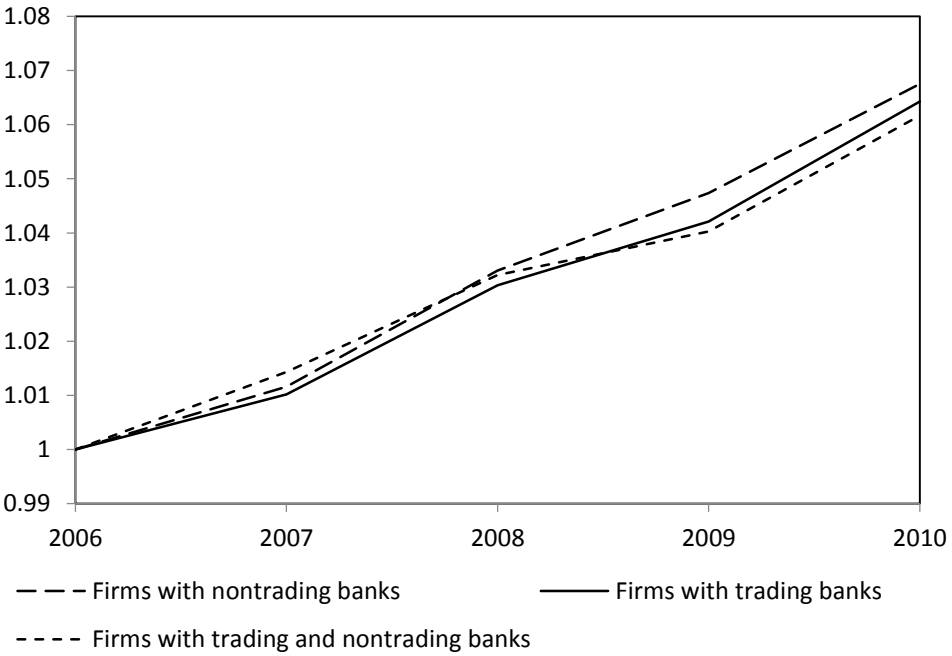
Notes: The figure shows the change in the banks' credit supply since 2006 on a logarithmic scale. We distinguish banks that do not report gains or losses from proprietary trading in 2005 or 2006 ("nontrading banks") and banks that do report gains or losses from proprietary trading in 2005 and 2006 ("trading banks").
Source: Authors' calculations are based on the bank financial accounts database Bankscope.

Figure B2: Growth of Long-Term Credit Supply from Trading and Nontrading Banks



Notes: The figure shows the change in the banks' *long-term* credit supply since 2006 on a logarithmic scale. Long-term credit supply refers to loans with a term of five years or more. We distinguish banks that do not report gains or losses from proprietary trading in 2005 or 2006 ("nontrading banks") and banks that do report gains or losses from proprietary trading in 2005 and 2006 ("trading banks").
Source: Authors' calculations are based on the bank financial accounts database Bankscope.

Figure B3: Growth of Fixed Assets of Firms with Trading & Nontrading Relationship Banks



Notes: In this figure, we distinguish firms whose relationship banks did not engage in proprietary trading in 2005 or 2006 ("firms with nontrading banks"), firms whose relationship banks did engage in proprietary trading in 2005 and 2006 ("firms with trading banks"), and firms with business relationships to both types of banks ("firms with trading and nontrading banks"). For the three groups of firms, the figure shows the change in the stock of fixed assets since 2006 (i.e., net real investment, on a logarithmic scale).
Source: Authors' calculations are based on the firm financial accounts database Dafne and the bank financial accounts database Bankscope.

Appendix C: Robustness checks

C.1 Robustness checks on the choice of instruments in Tables 4 and 5

Our results prove to be robust to the instrumental variables used. We consider alternative sets of instruments both in terms of timing and variation used. First, we vary our definition of the period of crisis. As explained in Section 4.2 of the main paper, to construct one of our instrumental variables, we interact the share of savings banks in distress in a firm's 2006 set of relationship banks with a dummy variable indicating the period of crisis. In our baseline estimations, this is defined as 2007 and onward (Tables 4 and 5 in the main paper). Here, instead, we define the period of crisis as 2008 only. The rationale behind this is that the financial crisis hit most severely in 2008 (collapse of Lehman Brothers). Results are shown in Table C1, columns (1), (3) and (5). Second, as discussed in Section 4.2 in the main paper, we explore the share of banks with U.S. affiliates in the firm's 2006 set of banking partners, interacted with 2008, as an additional excluded IV (IV set 4).[49] Results appear in Table C1, columns (2), (4) and (6). Third, we follow Abbassi et al. (2015) and use membership of banks to Eurex Exchange, the largest fixed-income trading platform in Germany, as an indicator for active presence in securities markets. We use this indicator dummy variable as an additional excluded instrument. The results (not shown in the table, available on request) remain similar. Hansen's over-identification test does not indicate invalid instruments in any of these estimations. Fourth, we use gains from proprietary trading as the only excluded instrument and find results qualitatively unchanged (available on request).

In an additional set of estimations (results available on request) we repeat these robustness checks for long-term credit supply and find results very similar to the ones reported in Table 4, columns (4) to (6).

From all these estimations, we conclude that the results are robust with respect to the choice of instruments.

[49] Here we use the share of banks with U.S. affiliates in the 2006 set of a firm's relationship banks as an additional control variable in both stages of the 2SLS estimations. When we use this control variable in our main specifications with only two instruments, the point estimate of the elasticity of interest is not significantly different from our baseline estimate in Table 4, column (2) and remains significant at the 1% level. We do not use this control variable in the main estimations because our bank data only provide information on affiliated banks for 2012, and we have to assume that a bank with (without) a U.S. affiliate in 2012 also had a (had no) U.S. affiliate in earlier years, which introduces some measurement error.

Table C1: Robustness Checks to Tables 4 and 5: Alternative Sets of Instruments

Dependent variable	Firm liabilities, growth rate		Real investment, growth rate		Employment, growth rate	
	(1)	(2)	(3)	(4)	(5)	(6)
L.Credit supply, growth rate	**0.106*** (0.035)**	**0.084*** (0.023)**	**0.079*** (0.027)**	**0.052*** (0.019)**	**0.054** (0.025)**	**0.031* (0.018)**
D.Business tax rate	0.203 (0.247)	0.224 (0.247)	-0.371* (0.217)	-0.339 (0.218)	-0.242 (0.256)	-0.209 (0.257)
L.D.Business tax rate	-0.049 (0.278)	-0.050 (0.277)	-0.578** (0.239)	-0.571** (0.238)	0.177 (0.267)	0.183 (0.265)
Share of savings banks affected by the crisis	0.002 (0.003)	0.001 (0.003)	0.005* (0.003)	0.003 (0.003)	0.010*** (0.003)	0.007** (0.003)
Share of banks with U.S. affiliates		-0.015* (0.008)		-0.023*** (0.007)		-0.025*** (0.007)
Year dummies	yes	Yes	yes	yes	yes	yes
Constant	0.013*** (0.003)	0.016*** (0.002)	-0.001 (0.003)	0.003 (0.002)	0.005 (0.003)	0.010*** (0.003)
Number of observations	291,079	291,079	291,079	291,079	36,843	36,843
Shea's partial R^2	0.07	0.16	0.07	0.16	0.09	0.18
1st stage *F*-statistic	1,299.98	6,500.67	1,299.98	6,500.67	415.10	1,229.52
Hansen test: *p*-value	0.20	0.96	0.15	0.79	0.60	0.83
Excluded instruments	IV set 3	IV set 4	IV set 3	IV set 4	IV set 3	IV set 4

Notes: For ease of exposition the coefficients of interest are in bold. Estimations are at the firm level. The dependent variable is the firm-specific growth rate in firm liabilities (columns (1) and (2)), fixed assets (columns (3) and (4)), and labor employment (columns (5) and (6)), respectively. The growth rates are log approximations. The growth rate of credit supply, the share of savings banks affected by the crisis, and the share of banks with U.S. affiliates pertain to the firm's relationship bank(s). We link firms to their banking partners via information on individual firm–bank relationships. If a firm has multiple relationship banks, we calculate the mean of the growth rates of their credit supply. D. indicates the first time difference of a variable, and L. indicates lagged values. Standard errors are robust to heteroscedasticity. ***/**/* indicate significance at the 1%/5%/10% levels. The time lag of the growth rate of credit supply is treated as endogenous. In the different specifications, we use alternative sets of excluded instruments:
IV set 3: Same as IV set 2 (used in Tables 4 and 5), but with a dummy variable indicating savings banks affected by the crisis among a firm's 2006 set of relationship banks in 2008 (instead of 2007 and onward).
IV set 4: Same as IV set 2 (used in Tables 4 and 5), but with the share of banks with U.S. affiliates among a firm's 2006 set of relationship banks in 2008 as additional excluded IV.
Summary: The table shows that our results on the effect of bank credit supply on firm liabilities, real investment, and labor employment (reported in Tables 4 and 5) are robust to the choice of instruments.
Source: Authors' calculations are based on the firm financial accounts database Dafne and the bank financial accounts database Bankscope, 2006–2010; (lagged) first differences also use 2005 (2004).

C.2 Robustness checks on specifications choices in Table 4

In a first robustness check, we use the growth rate in firms' bank liabilities instead of firms' total liabilities as the dependent variable. Within our sample, this more detailed information is only available for 27,876 observations. After removing outliers pertaining to bank liabilities (10% of this subsample), the point estimate of the elasticity of bank liabilities is 0.109 and, thus, identical to the baseline point estimate in Table 4, column (2), but it comes with a fairly large standard error and becomes insignificant due to the small sample size.

In a second robustness check, we also include the lagged growth rate of total assets (as a measure of the change in firm size) and the lagged first difference in the ratio of fixed assets

over total assets (as a measure of the change in tangibility or collateral). The point estimate and standard error of the elasticity of interest remain virtually unchanged compared with our main specification in Table 4, column (2). We do not include these controls in the main estimations because of potential endogeneity concerns (which would be even more pronounced in the investment equation).

C.3 Robustness checks concerning specific firms and banks

Firms owned by financial institutions: One might be concerned that some firms not only have a lending relationship with their banking partners but that these banks also own shares of the firms' equity. In this case, the effects of bank distress on firm borrowing and investment might not only work through the bank lending and firm borrowing channel, but also directly through the bank's ownership share. In two additional robustness checks, we exclude all firms from the sample that have i.) banks among their owners; and ii.) one of the following among their owners: any financial institutions or private equity or venture capital firms. The results with respect to firm liabilities and investment remain similar to the baseline results, so ownership does not appear to confound the effects we measure.

Subsidiaries of foreign banks or real estate banks: Furthermore, subsidiaries of foreign banks or real estate banks may be affected by the financial crisis through their parent organizations. To assess whether this influences our results, in two additional robustness checks, we exclude firms with a relationship bank that is a subsidiary of i.) a foreign bank; and ii.) a real estate bank, from the estimation sample. Again we obtain similar results.

C.4 Robustness checks using the maximum credit supply

In the main estimations, as the key explanatory variable, we use the average growth rate of credit supply if a firm has more than one relationship bank. One might argue that as long as one of the relationship banks is healthy, the firm should not be affected by the problems of the other banking partners; a healthy relationship bank could make up for any contraction in loan supply from the firm's other relationship banks. Therefore, in an additional robustness check, we use the *maximum* of the growth rates of credit supply from all banking partners instead of the average—that is, we consider a firm's best-performing bank only. The point estimates from these regressions (provided in Table C2) are statistically indistinguishable from our baseline estimates. In summary, we conclude that our results are robust to the choice of instruments and to specification and sample selection choices.

Table C2: Robustness Check: Credit Growth of the Best-Performing Relationship Bank

2SLS regressions of firms' liabilities, investment and employment growth rates on the *maximum* growth rate in credit supplied by its banking partners

Dependent variable:	Firms' liabilities, growth rate			Fixed assets, growth rate		Employment, growth rate	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Credit supply, maximum growth rate (i)	0.019						
	(0.031)						
L.Credit supply, max. growth rate (ii)	**0.161*** **	**0.130*** **	**0.130** **	**0.086*** **	**0.094** **	**0.061** **	**0.044**
	(0.048)	**(0.042)**	**(0.059)**	**(0.033)**	**(0.047)**	**(0.030)**	**(0.034)**
D.Business tax rate	0.206	0.196	0.732	-0.374*	-0.649*	-0.232	0.149
	(0.247)	(0.247)	(0.449)	(0.217)	(0.377)	(0.255)	(0.371)
L.D.Business tax rate	-0.019	-0.023	0.096	-0.573**	-0.763**	0.202	0.384
	(0.279)	(0.280)	(0.400)	(0.240)	(0.344)	(0.269)	(0.342)
L.D.Sales			0.137***		0.116***		0.108***
			(0.008)		(0.006)		(0.010)
Share of savings banks affected by the crisis	0.004	0.003	0.001	0.005**	0.013***	0.012***	0.013**
	(0.003)	0.130***	(0.005)	(0.003)	(0.005)	(0.003)	(0.006)
Year dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Constant	0.003	0.007	0.011	-0.004	0.004	-0.001	-0.009
	(0.006)	(0.005)	(0.007)	(0.004)	(0.006)	(0.006)	(0.008)
Number of observations	291,079	291,079	88,153	291,079	88,153	36,843	18,910
Shea's partial R^2 for (i)	0.07	0.03	0.04	0.03	0.04	0.04	0.05
1st stage *F*-statistic for (i)	102.39	384.00	327.67	384.00	327.67	186.86	80.68
Shea's partial R^2 for (ii)	0.03						
1st stage *F*-statistic for (ii)	267.51						
Hansen test: *p*-value	0.41	0.78	0.19	0.53	0.31	0.43	0.56
Excluded IVs	IV set 1	IV set 2	IV set 2	IV set 2	IV set 2	IV set 2	IV set 2

Notes: For ease of exposition the coefficients of interest are in bold. Estimations are at the firm level. The dependent variable is the firm-specific growth rate either in liabilities, in fixed assets or in labor employment. The growth rates are log approximations. The growth rate of credit supply and the share of savings banks affected by the crisis pertain to the firm's relationship bank(s). We link firms to their banking partners via information on individual firm–bank relationships. If a firm has multiple relationship banks, in this table we use the *maximum* growth rate of (long-term) credit supplied by the banks. D. indicates the first time difference of a variable, and L. indicates lagged values. Standard errors are robust to heteroscedasticity and reported in parentheses. ***/**/* indicate significance at the 1%/5%/10% level. The growth rate of credit supply and its first time lag (L.) are treated as endogenous. In the different specifications, we use alternative sets of excluded instruments:

IV set 1: Proprietary trading gains and the share of savings banks affected by the crisis in 2007 and onward among a firm's 2006 set of relationship banks. Contemporaneous and lagged variables.

IV set 2: As IV set 1, but with lagged variables only.

Summary: We obtain similar results as in the main estimations in Tables 4 and 5 in the main paper when we use the *maximum* growth rate in credit supplied by a firm's banking partners instead of the mean, i.e., when we consider the best performing relationship bank only.

Source: Authors' calculations are based on the firm financial accounts database Dafne and the bank financial accounts database Bankscope, 2006–2010; (lagged) first differences also use 2005 (2004).

C.5 Robustness checks concerning the adjustment channels

Table C3: Change in Number of Banking Partners Depends on Tangibility & Firm Size

2SLS regressions

Dependent variable: Change in no. of banking partners	Tangibility		Firm Size		
	Above median	Below median	Above median	Above median	Below median
	(1)	(2)	(3)	(4)	(5)
Credit supply, growth rate	-0.064***	-0.016	-0.048*	-0.042*	-0.010
	(0.023)	(0.021)	(0.025)	(0.025)	(0.016)
Credit supply, growth rate *x* indicator for publicly listed firms (ii)				-1.124	
				(0.733)	
D.Business tax rate	-0.379**	-0.262	-0.120	-0.134	-0.496***
	(0.181)	(0.174)	(0.216)	(0.217)	(0.130)
L.D.Business tax rate	0.211	0.205	0.103	0.112	0.318**
	(0.195)	(0.182)	(0.229)	(0.231)	(0.133)
Two banking partners in 2006	-0.028***	-0.028***	-0.029***	-0.029***	-0.031***
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
Three banking partners in 2006	-0.077***	-0.070***	-0.077***	-0.077***	-0.075***
	(0.007)	(0.006)	(0.005)	(0.005)	(0.009)
Four banking partners in 2006	-0.157***	-0.164***	-0.165***	-0.164***	-0.152***
	(0.024)	(0.024)	(0.018)	(0.018)	(0.056)
Five banking partners in 2006	-0.340***	-0.363***	-0.346***	-0.345***	-0.708**
	(0.067)	(0.079)	(0.052)	(0.052)	(0.318)
Six banking partners in 2006	-0.642***	-0.294**	-0.526***	-0.527***	
	(0.170)	(0.144)	(0.123)	(0.123)	
Share of savings banks affected by the crisis	0.004**	0.004**	0.005**	0.005**	0.004***
	(0.002)	(0.002)	(0.002)	(0.002)	(0.001)
Year dummies	Yes	Yes	Yes	Yes	Yes
Constant	-0.001	-0.003	-0.010***	-0.011***	0.008***
	(0.003)	(0.003)	(0.003)	(0.003)	(0.002)
Number of observations	79,779	78,981	79,713	79,713	79,047
Shea's partial R^2 (i)	0.04	0.03	0.04	0.04	0.03
1st stage *F*-statistic (i)	19.78	21.38	24.79	21.59	17.33
Shea's partial R^2 (ii)				0.01	
1st stage *F*-statistic (ii)				7.81	
Hansen test: *p*-value	0.47	0.12	0.24	0.24	0.47
Excluded instruments	IV set 5	IV set 5	IV set 5	IV set 6	IV set 5

Notes: For ease of exposition the coefficients of interest are in bold. Estimations are at the firm level. D. indicates the first time difference of a variable, and L. indicates lagged values. Standard errors are robust to heteroscedasticity. ***/**/* indicate significance at the 1%/5%/10% level. The growth rate of credit supply is treated as endogenous. We use the following set of excluded instruments:

IV set 5: Proprietary trading gains and share of savings banks affected by the crisis in 2007 and onward among a firm's 2006 set of relationship banks.

IV set 6: Same as IV set 5, additionally including the interaction term between the indicator for publicly listed firms and the proprietary trading gains among a firm's 2006 set of relationship banks.

Summary: The table presents estimations like in Table 8 of the main paper, but using the growth rate in credit supply instead of the share of banks with proprietary trading losses as the explanatory variable of interest. The results are qualitatively similar.

Source: Authors' calculations are based on the firm financial accounts database Dafne and the bank financial accounts database Bankscope, 2006–2010; (lagged) first differences also use 2005 (2004).

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