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## The Effect of Restrictive Bank Lending on Innovation: Evidence from a Financial Crisis

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## The Effect of Restrictive Bank Lending on Innovation: Evidence from a Financial Crisis\*

### Abstract

Using unique micro-data on German firms, this paper estimates the effect of restrictive bank lending on innovation. In the German three-pillar banking system, comprised of commercial banks, credit unions, and savings banks, firms were differently affected in their ability to raise external debt during the financial crisis depending on the pillar to which their main relationship bank belonged. Using this institutional feature as an instrument for credit access reveals that restrictive bank lending increases a firm's probability of discontinuing innovation projects by 21.6 percentage points.

JEL Code: G01, G21, G30, O16, O30.

Keywords: Financial crisis, innovation, credit constraints, difference in differences, instrumental variables.

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## 1) Introduction

Does restrictive bank lending reduce innovation activity? If the answer is “yes,” then a relatively short period of financial distress could have important implications for long-term growth. When identifying the effect of external finance on innovation, however, it is insufficient to simply rely on the actual use of external finance as a measure for credit access. This rather captures the equilibrium between demand and final supply of external funds and is therefore highly endogenous to the characteristics of the firm, those of the bank, and other factors unobservable to the researcher (Rajan and Zingales 1998). Additional external finance enables firms to increase their R&D and develop new technologies, but new technologies also induce more R&D and increase the need for external finance. The ultimate goal is to successfully isolate the supply effect (Brown et al. 2009).

This paper exploits an institutional feature of the German banking system that led to variation in firms’ credit access during the recent financial crisis depending on whether their main relationship bank is a commercial bank or a credit union. This variation can be used in an instrumental variables approach with a difference-in-difference-like first stage to estimate the causal effect of restrictive bank lending on innovation.

In the first phase of the financial crisis, only financial markets were affected and real economy effects had not yet occurred. Banks had to write off massive amounts of money and reduce the active positions in their balance sheets. However, not all banks were hit equally hard. The German banking system is based on three pillars: commercial banks, credit unions, and savings banks. The three types engage in significantly different business practices. This paper focuses on the difference between commercial banks and credit unions as it is the most pronounced. Credit unions do not invest in foreign assets to the same extent as commercial banks because they are legally bound to foster their members, which usually reside in the same region as the credit union. They also obtain a larger fraction of their capital directly from savings accounts, which are a rather cheap and stable method of refinancing. This, importantly, continues to function even when the interbank market collapses, on which commercial banks primarily rely to refinance their operations. These institutional features mean that credit unions did not have to shrink their balance sheets and reduce their lending during the financial crisis to the same extent as did commercial banks.

During this first phase of the financial crisis, firms were not affected in their daily operations except in regard to external capital generation. Given the strong and stable relationship

between a firm and its main bank in Germany, firms are affected in their ability to raise external debt to the same degree that their main bank is affected by the financial crisis.

The ifo business survey collects direct information about a bank's lending situation, as well as information about its main bank relation and its innovation activity. This information provides a unique opportunity to assess the effect of restrictive bank lending directly without having to use proxies to define a firm as credit constrained. In an instrumental variable (IV) setting we can use differences in the development of a firm's individual bank lending situation during the financial crisis depending on whether its main relationship bank is a commercial bank or a credit union to causally estimate the effect of restrictive lending on innovation activity. The panel structure of the dataset lets us follow individual firms over several years and also allows for the inclusion of individual firm fixed effects.

The results provide first evidence that a relatively short period of restrictive bank lending has long-term consequences for an economy through the channel of reduced innovation activity. In an environment of restrictive bank lending, firms are 21.6 percentage points more likely to discontinue an already ongoing innovation activity, a finding that should be taken into consideration by any politician or decision maker dealing with a financial crisis. This effect is much larger than indicated by simple OLS estimation and can be interpreted in a causal way under the assumption of parallel trends in innovation activity by firms with a commercial bank relationship and those with a credit union as their main bank, in absence of the financial crisis.

The remainder of the paper is organized as follows. Section 2 provides a short overview of the literature relevant to this article. Section 3 describes the dataset. Section 4 provides a first starting point by estimating a simple OLS model. Section 5 introduces the identification strategy; the results are presented in Section 6. Several robustness tests are conducted in Section 7. Section 8 concludes.

## 2) Finance and Innovation

How the financial system affects long-term growth is a topic of ongoing debate in the literature. Some economists are of the opinion that the financial system is not at all important for growth (Lucas 1988) and that it is the economic development that causes the development of the financial system (Robinson 1952). However, many economists are convinced that the financial system plays a critical role in generating growth as only the financial system can transform savers' liquidity into long-term capital investments (Hicks 1969; Bagehot 1973; Schumpeter 1912).

The last few years have seen more of a consensus among economists that an economy's long-term growth is indeed influenced by the financial system (Levine 2005). In growth models such as those of Romer (1990), Grossman and Helpman (1991), and Aghion and Howitt (1992), the financial system can influence steady-state growth through altering the rate of technological innovation. An extensive overview of the channels through which the financial system influences long-term growth is provided in Levine (1997). As to empirical evidence on the subject, King and Levine (1993a, 1993b, 1993c) use a cross-section of 80 countries to investigate whether financial development affects growth. In their studies, all indicators of financial development are significantly associated with growth. To evaluate the direction of causality, the authors use lagged development of the financial system and show that the financial depth in 1960 can predict economic growth, capital accumulation, and productivity improvements for the next 30 years. Rajan and Zingales (1998) show that capital-dependent industries evolve more successfully in countries having better developed financial systems. They argue that the main driver of such a phenomenon is that in such countries, investment opportunities are more easily identified.

Another important effect of a well-developed financial system is the mediation of economic cycles. Aghion et al. (2011) state that investment is pro-cyclical under credit constraints but countercyclical in their absence, a result confirming the findings of Fazzari et al. (1988). This effect is strongest in sectors that rely heavily on external finance. The R&D investment share in credit-constrained firms falls during recessions, but does not increase to the same degree during upswings. In an instrumental variable approach similar to the one used in this paper, Paravisini et al. (2011) find a significant negative effect of reduced bank credit supply on international trade for a large sample of Peruvian firms.

The effects of macroeconomic instability, such as instabilities stemming from the financial system, are well studied when it comes to productivity, firm survival, health, mortality, and crime, but little is known about the consequences of instability for technological discovery (Lamoreaux and Levenstein 2011). Savignac (2008) finds a negative relationship between financial constraints and innovation after controlling for whether the firms actually intend to be innovators, using a French dataset that includes direct measures for credit constraints. Benfratello et al. (2008) confirm a positive influence of bank development in Italy, proxied by branch density, on innovation, which is most pronounced for sectors with greater need for external capital. Using a firm panel covering many countries and using, among other measures, overdue payments to suppliers as an instrument for credit constraints, Gorodnichenko and Schnitzer (2010) find that financial constraints restrain the innovation activity of domestically owned firms and prevent them from catching up to the technological frontier. Campello et al.'s (2010) international survey of more than 1,000 chief financial officers finds that during the financial crisis, financially constrained firms tended to plan deeper cuts in tech spending, employment, and capital investment and that most of them had to forego attractive investment opportunities due to their inability to raise external capital. This inability seems to be mainly driven by quantity constraints and only to a lesser extent by price constraints.

To date, most empirical studies on the topic use proxies for firms' credit constraints. Only very seldom are direct measures available (Savignac 2008). Fazzari et al. (1988) define firms as being credit constrained when they pay no dividends, a situation that is assumed to arise because the firms need all available money for their own survival. Hall and van Reenen (2000) look at R&D induced by tax changes and find a stimulating effect of tax credits on R&D, with an elasticity around unity. Gorodnichenko and Schnitzer (2010) use overdue payments to suppliers as an instrument for credit constraints. In this paper, we follow Savignac (2008) and Campello et al. (2010) and use a direct measure of firm's credit constraint. This method overcomes measurement problems and allows for a straightforward interpretation of the results.

Also, the issue of the direction of causality is still not completely resolved in the literature. On the one hand, financial development might cause innovation and growth; on the other hand, the financial system might develop in anticipation of future innovation and growth. Even though some studies tackle endogeneity quite well, such as Gorodnichenko and Schnitzer (2010), further causal evidence is needed on this issue.

Firms usually have many possible ways of financing innovation activity; bank finance is not the only way of raising external capital. There is disagreement in the literature as to whether firms should use equity or debt to finance innovation activity (Hellmann and Stiglitz 2000; Ueda 2004). However, evidence suggests that bank finance plays at least some role in innovation financing. According to Myers and Majluf (1984), there is a sort of financing preference “pecking order.” Firms prefer to finance their innovations through internal cash flows. If those are insufficient, firms prefer debt over equity because ownership control can be retained. If debt financing is not feasible, firms are forced to give up a certain amount of control and their (potentially high) future earnings in a bid to obtain equity financing. The same order of preferences is postulated by Bolton and Freixas (2000). According to them, entrepreneurs generally prefer debt finance but are often turned down by banks and have no choice other than turning to equity financing. Small firms are especially dependent on bank finance. Sharma (2007) finds that R&D in small firms is associated with bank development but not with measures of stock market development.

In Germany, bank finance plays a large role in innovation financing. This is because the relations between firms and their main banks are usually very close. It is due to these intense and long-lasting bank-firm relationships, during which banks acquire an enormous amount of knowledge about a firm’s potential, that banks are willing to provide credit, even for risky innovation projects. The literature generally confirms the importance of an intense bank-firm relationship for the availability of credit (Berger and Udell 1995; Petersen and Rajan 1994; Elsas and Krahnert 1998; Harhoff and Körting 1998). Furthermore, the German tax system allows deduction of rent payments but not deduction of fictive rent payments to equity, a system that makes debt finance favorable (Hall 2009). Spielkamp and Rammer (2009) show that apart from internal finance, which is always preferred and used to the extent possible, a higher percentage of German innovative enterprises use debt finance (44 percent) than equity finance (25 percent).

In summary, it seems that bank finance plays a major role in the financing of innovation activity, especially, but not exclusively, for small and medium-sized firms. This paper concentrates on bank finance to evaluate the effect of credit constraints on innovation, but it is important to keep in mind that other financial instruments are available to firms, even though they seem most important for very large businesses. However, as the conclusions drawn in this paper are of a general nature, the source of the exogenous variation in external capital is of only minor concern.

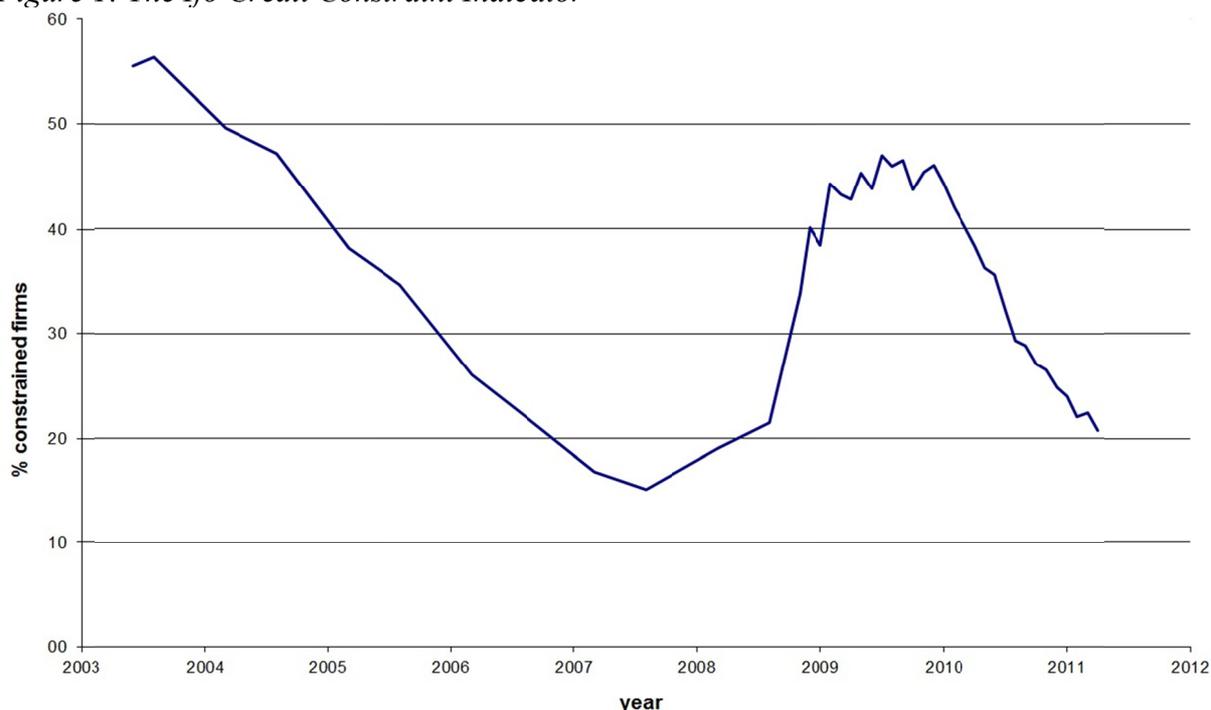
### 3) Firm-Level Data on Financing Constraints and Innovation

The dataset used in this paper builds on the Ifo Business Survey, which is conducted monthly by the Ifo Institute for Economic Research in Munich for the purpose of making predictions about the German business climate. The Ifo Business Survey dataset includes data on the manufacturing, construction, and services sectors, but this paper focuses exclusively on the manufacturing sector. Every month, around 3,000 manufacturing firms report their current business situation as well as their expected business situation. Firms have the opportunity to answer the survey either online or in a paper-based format. The panel spans many decades, thus guaranteeing a solid database that is remarkably representative of the German economy. In addition to the business situation variables, this paper uses some special questions that are included in the Ifo Business Survey. Each December, firms are questioned about their innovative activity in the preceding year. They are asked to indicate whether they realized an innovation, discontinued an innovation activity, have finished planning an innovation, are currently planning an innovation, or do not intend to innovate at all. The question is asked separately for process and product innovations. Since 2003, firms have been asked to give an appraisal of the current bank lending situation. Firms state whether they perceive banks' willingness to provide credit to firms as accommodating, normal, or restrictive.<sup>1</sup> The question was initially asked twice a year, beginning in June 2003, but has been included in the regular monthly set of questions since November 2008. Figure 1 shows the fraction of all answering firms over time that perceived the lending situation as restrictive. This indicator is known as the Ifo Credit Constraint Indicator. Obviously, the financial crises, which started in August 2007 with the subprime crisis and peaked with the Lehman Brothers' insolvency in 2008, had huge effects on the lending behavior of banks in Germany. On aggregate, manufacturing firms in Germany face a lending situation since the crisis that is worse than before the crisis.

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<sup>1</sup> The English translation of the German question is: "How would you assess the current willingness of banks to extend credit to businesses?"

Figure 1: The Ifo Credit Constraint Indicator



Source: Ifo Business Survey. The graph shows the fraction of all firms reporting restrictive bank lending. Own calculations based on 11,413 observations from 2,040 firms.

In June 2009, all firms were asked about their main bank relation. They were asked whether they have a main bank with which they have a close connection and, if so, what type of bank it is.<sup>2</sup> Firms could choose between “savings bank,” “credit union,” “commercial bank,” “federal state bank,” or “other.”<sup>3</sup> Around 41 percent of all reporting firms have intensive business relations with a savings bank, around 20 percent with a credit union, and around 34 percent with a commercial bank (Table 1). Keep in mind that the German economy is heavily reliant on bank finance compared to the United States or Great Britain, which makes the banks’ willingness to lend even more important for investments in innovative activity in Germany than elsewhere (Hirsch-Kreinsen 2011). This situation may partly be due to the fact that the German tax system allows for a deduction of interest on external capital but not for a deduction of fictive interest when a firm uses internal or equity finance (Fischer 2007).

The average firm in the dataset has 196 employees. All firms with more than 1,000 employees are dropped for three reasons. Firms above that threshold show almost no variation in their innovation behavior. Consequently, they are not especially useful for identifying the effect of credit constraints on innovation activity. These firms also predominantly report commercial banks and federal state banks as their main bank relation. Since we want to use variation

<sup>2</sup> The English translation of the question is: “Do you have a main bank relation (long-time and intensive business relation with a bank)?”

<sup>3</sup> Multiple answers were possible.

between the lending behavior of credit unions and commercial banks in this paper, because this is the most clear-cut difference, firms with more than 1,000 employees are again not particularly useful for our identification strategy. Additionally, firms with more than 1,000 employees are most likely able to obtain financing through channels other than the bank market. Restricting our sample to firms with less than 1,000 employees assures that firms are actually relying on bank finance to a large extent.

About 79 percent of all firms in the dataset are located in the western federal states of Germany. On average, 64 percent of firms are innovators, with at least one realized innovation during the year. The sample firms' average sales volume is around 35.5 million Euros.

*Table 1: Descriptive statistics*

	N	firms	mean	min	max
bank lending is restrictive	16460	3732	0.413	0	1
innovation realized	10790	2849	0.643	0	1
... process innovation realized	10790	2849	0.429	0	1
... product innovation realized	10790	2849	0.553	0	1
innovation discontinued	10790	2849	0.033	0	1
... process innovation discontinued	10790	2849	0.018	0	1
... product innovation discontinued	10790	2849	0.022	0	1
employees	17905	3881	195.5	1	1000
not exporting	17881	3881	0.237	0	1
west	17905	3881	0.790	0	1
demand situation	17902	3881	-0.026	-1	1
state of business (current)	17903	3881	-0.043	-1	1
state of business (expected)	17889	3880	0.011	-1	1
sales (mil. Euros)	4537	1616	35.55	0	4924.03
main bank is...					
... credit union	11413	2040	0.202	0	1
... savings bank	11413	2040	0.409	0	1
... federal state bank	11413	2040	0.069	0	1
... commercial bank	11413	2040	0.338	0	1
... other	11413	2040	0.099	0	1

Source: Ifo Business Survey waves 2003–2009, averages of annually aggregated values, own calculations.

This paper uses the 2003 to 2009 waves to estimate the effect of restrictive bank lending on innovation. This sample period shows clear variation in the financial market that can be used for identification. All monthly data are aggregated on an annual basis. Simple average values are computed for employees, sales, and the reported demand situation, as well as for the current and expected state of business. The binary variable indicating whether bank lending is reported to be restrictive or not takes the value of 1 if a firm reports a restrictive lending situation at least once in the corresponding year. Due to the identification strategy, which is explained in greater detail in Section 5, we use only those firms that report either a commercial bank or a credit union as their main bank. As a result, the final estimation sample

is an unbalanced panel comprised of 772 firms that can be observed, on average, over 4.6 years.

To capture any immediate impact of restrictive bank lending on innovation, a highly responsive measure is needed. This paper uses *discontinued innovation activity* as the main outcome variable. This binary variable is among the first measures to react to severe restrictions stemming from the financial sector and takes the value of 1 if a firm reports that it discontinued an innovation activity during the reporting period. This enables us to observe and identify a direct and immediate effect of restrictive bank lending. Discontinuing an innovation activity implies that resources were sunk into the activity without producing any valuable results, which is not only inefficient and growth reducing for the individual firm but for the whole economy.

Usually, patent counts or direct survey measures for introduced innovations are used to measure effects on innovation activity. However, for a couple of reasons, neither is well suited to this study. Patents usually take quite some time before they are granted and thus patent statistics are not a good contemporaneous indicator of a firm's current innovation activity. Additionally, patents capture inventions, not necessarily innovations, as it is not entirely clear whether the patented product or process will actually be used by the firm or whether the patent has only been obtained to gain leverage against competitors. Direct measures for successfully *introduced* innovations, which are also available in the Ifo Business Survey, suffer from the same lag problem as patent counts. Innovations usually need time to be developed to the extent where they can be introduced. Using successfully introduced innovations as an outcome measure would most likely prevent the identification of immediate effects of restrictive bank lending and only identify the effect of past bank lending.

Only a measure of starting an innovation, as it is available in the Ifo Innovation Survey, would also serve the purpose to identify immediate effects. The Ifo Innovation Survey is a special survey which is carried out annually at the Ifo Institute to assess the innovation activity of firms in even greater detail. Firms participating in the innovation survey can be matched with their corresponding records in the business survey, given that they have responded to both surveys. We use this measure as a robustness test at a later stage to verify our results. Unfortunately, this measure is available for only a small number of firms in our sample and therefore the statistical power of this model is somewhat limited.

#### 4) The Association Between Restrictive Bank Lending and Discontinued Innovations

A simple OLS model is used to provide a starting point for the investigation into the effect of restrictive bank lending on innovation. Column 1 in Table 2 shows the estimation results for the simplest OLS estimation. We identify a positive coefficient of 0.0128, which is significant at the usual levels. A restrictive lending situation is associated with a 1.28 percentage point increase in the probability of discontinuing an innovation. In this setting, we control for time fixed effects, industry fixed effects at the two-digit NACE level, and size class fixed effects, as is the case for all regressions in this paper. In Column 2, we further control for possible real economy effects in order to isolate the effect stemming from the financial system. We include the reported demand situation compared to the preceding quarter (better, unchanged, worse), a binary indicator for whether a firm exports any goods, a binary indicator for whether a firm is located in the western part of Germany, and the current state of business (good, satisfying, bad), as well as the expected state of business for the next six months (more favorable, unchanged, less favorable). Including these controls does not much change the results.

*Table 2: OLS results*

	(1)	(2)	(3)	(4)
dependent variable:	innovation discontinued	innovation discontinued	product innovation discontinued	process innovation discontinued
restrictive lending	0.0128*** [0.00444]	0.00951** [0.00444]	0.00398 [0.00357]	0.00595* [0.00312]
west	-	-0.00551 [0.0105]	0.000945 [0.00794]	-0.00795 [0.00811]
not exporting	-	-0.00204 [0.00744]	0.000276 [0.00612]	-0.00644 [0.00457]
demand situation	-	-0.00589 [0.00423]	-0.00393 [0.00336]	-0.00279 [0.00304]
state of business	-	-0.0113*** [0.00365]	-0.00719** [0.00294]	-0.00641** [0.00267]
state of business (expected)	-	-0.00352 [0.00417]	-0.00232 [0.00332]	-0.00475 [0.00296]
R-squared	0.013	0.016	0.012	0.012
observations	10246	10238	10238	10238
firms	2764	2764	2764	2764

Notes: OLS estimation on the basis of the Ifo Business Survey. Robust standard errors clustered at the firm level in brackets. Fixed effects for years, two-digit industry code, and size class included in all specifications. \*\*\* p<0.01, \*\* p<0.05, \* p<0.1

The outcome variable can be further split into discontinued product and process innovations. Columns 3 and 4 of Table 2 show the results for those two refined outcome measures. The effect is pronounced and statistically significant for discontinued process innovations, but insignificant for product innovations.

However, the OLS effects are subject to many caveats. First, reverse causality is likely prevalent. Firms reporting restrictive bank lending might actually have trouble obtaining bank credit *because* they discontinue their innovation activity. They might also be unable to obtain bank credit simply because they are trying to innovate, which is a risky business in itself. In these situations, the effect of restrictive bank lending on innovation would be overestimated in the OLS model. However, it might also be that firms that discontinue innovations but at least try to innovate are seen as having the potential for success in the future and therefore are given better access to credit. In this situation, the OLS model would underestimate the true effect of restrictive bank lending. These problems are partially circumvented by the design of the data. Firms are asked about the general willingness of banks to provide credit to businesses in general and not explicitly about banks' willingness to provide credit to them. Thus, even firms that individually face restrictive access to bank credit might report the situation as not restrictive if they are aware of other firms successfully obtaining credit. Nevertheless, the problem is not completely solved.

The second source of potential bias in the OLS estimation is selection bias. On the one hand, firms reporting restrictive bank lending might be a selected group concerning their innovation activities or, on the other hand, firms reporting discontinued innovations might be a selected group concerning their external debt situation. For instance, firms discontinuing innovation projects might need less external finance as a result and therefore not report that lending is restricted. In this case, the OLS model would underestimate the effect of restrictive bank lending on discontinued innovation.

Another source of bias might be omitted variables that influence both the discontinuing of innovations as well as the perceived and reported bank lending situation and that are unobservable by the researcher; for example, the risk averseness of a firm's management. If management is especially risk averse, the firm might discontinue innovation projects more often but might also enjoy a more favorable lending situation. A bank would know that its investment in the firm can most likely be recouped as the firm's management is not going to make any overly risky decisions. This would lead the OLS model to underestimate the true effect of restrictive bank lending on innovation activity. Finally, systematic measurement error in the reported restrictive lending variable could play a role if firms that discontinue their innovations have a different perception of the lending situation than firms that do not discontinue their innovations. To tackle these potential biases we need an identification strategy that utilizes exogenous variation in the restrictive lending variable.

## 5) A Unique Variation of Credit Provision in the German Banking Sector During the Financial Crisis

Traditionally, the banking system in Germany is divided into three pillars: the commercial banking sector, the credit union sector (*Genossenschaftsbanken*), and the savings banks sector (*Sparkassen*). Credit unions and savings banks differ from their commercial counterparts in their commitment to promote regional businesses and regional growth. However, this paper focuses on the difference between commercial banks and credit unions as this is most clear cut.

Credit unions are community-based banks organized in a cooperative structure. They are owned and controlled by their members in a one-member-one-vote system. Usually, only members are allowed to receive a loan from a credit union or deposit money in it. As a consequence, credit unions have always been committed to provide superior services to their members and help them prosper economically. Even by law, credit unions are obligated to act in a manner that will foster the prosperity of their members.<sup>4</sup> As members usually reside in the same region where the credit union is located, this induces a regional dimension to all the credit union's actions. Credit unions were originally developed in Germany during the 19<sup>th</sup> century by Herman Schulze-Delitzsch and Friedrich Wilhelm Raiffeisen. Schulze-Delitzsch created his first credit unions in cities; Raiffeisen focused on the rural parts of the country. Credit unions served all classes of people, including the middle class and the poor, which was not the case for the typical commercial bank at that time. The regional dimension, as well as their ownership structure, means that credit unions tend to invest in regional projects and do not engage in risky projects in foreign countries. Consequently, one would expect them to have been hit the least hard by the financial crisis that originated in the U.S. real estate market.

The main goal of credit unions is to foster their members and, at least in comparison to commercial banks, not to make profits and expand by any and all means. They also have a tightly woven branch network and obtain a large fraction of their financial means through the savings deposits of individual persons (see Table 3). Those savings are usually stable and rather cheap to finance. Big commercial banks generally do not have such a strong savings deposit position and predominantly rely on the interbank market to refinance their operations. This works perfectly well in times when banks are willing to lend to each other, but creates enormous problems when the interbank market collapses, as it did during the recent financial

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<sup>4</sup> §1 Genossenschaftsgesetz (credit union law).

crisis. The importance of banks' deposits-to-assets ratio is demonstrated in a recent paper by Ivashina and Scharfstein (2010) dealing with bank lending behavior during the financial crisis. The authors demonstrate that banks with a deposits-to-assets ratio one standard deviation below the mean reduced their loan originations by 49 percent, while banks with a deposits-to-assets ratio one standard deviation above the mean reduced their lending by only 21 percent. The authors further state that banks with a strong deposit base are in the best position to continue funding those credit lines during the crisis on which they agreed before the crisis.

*Table 3: Savings deposits and total lending*

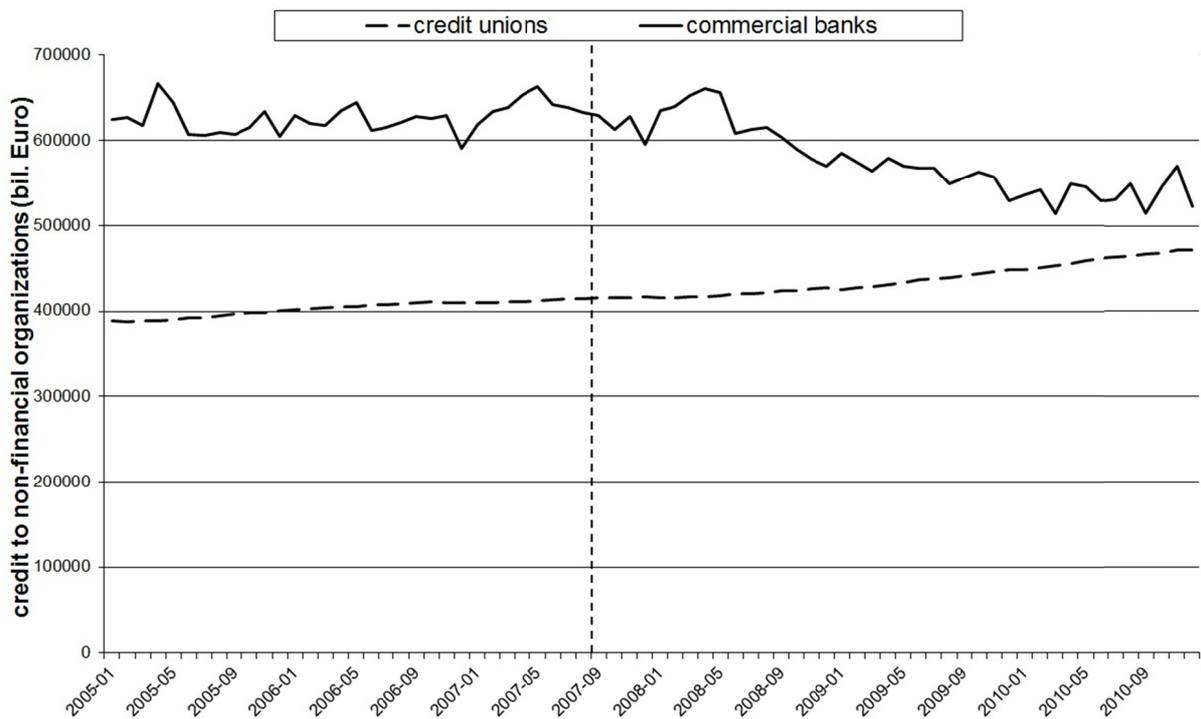
	all banks	credit unions	big commercial banks
loans to non-banks (bil. Euro)	3,810,493	411,987	580,961
... percentage of all loans	100%	10.8%	15.2%
savings deposits of non-banks (bil. Euro)	588,660	173,364	58,035
... percentage of all saving deposits	100%	29.5%	9.9%
saving deposits per loan	15.4%	42.1%	10.0%

Note: Average values for the period 2003–2010.

Source: Time series database, Deutsche Bundesbank.

This specific feature of the German banking sector leads to an expectation that the different pillars of the banking sector do not react in the same way to financial crisis hits. Credit unions are bound by duties of loyalty and are deeply integrated into their regional economy. They know their customers, their savers, and their businesses, and their customers are, in turn, loyal to them. Because credit unions had not invested as much in risky assets prior to the crisis, they did not have to write off as much as did commercial banks. They also obtain a large fraction of their means from savings deposits, which do not fluctuate much over time. We would therefore expect *ex ante* that the credit union lending reacts less to a crisis than the lending of commercial banks. Figure 2 illustrates the declining lending total of commercial banks in Germany during the most recent financial crisis. Credit unions, on the other hand, seem to be unaffected by this declining trend, as expected.

Figure 2: Time series of total lending to non-financial organizations

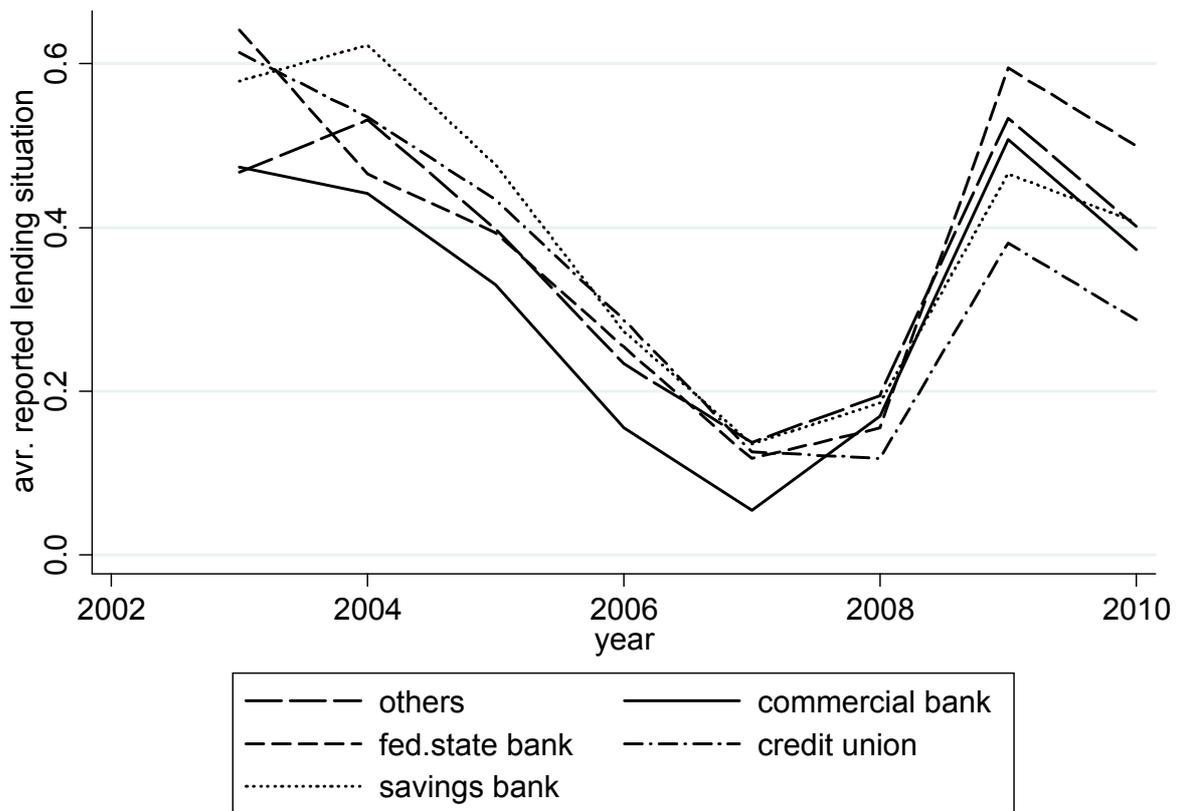


Source: Deutsche Bundesbank.

Figure 3 graphs the familiar credit constraint indicator split by the main bank relation of firms.<sup>5</sup> The anticipated ex ante pattern is clearly visible. Credit unions are hit least hard by the crisis. They tend to offer more restrictive access to credit before the crisis compared to commercial banks, but offer more favorable conditions after the crisis. This is not because their lending became more lax, but because the commercial banks restricted their lending even more in the course of the crisis. The picture before the crisis matches perfectly the perception that cost leadership is not a strategy pursued by credit unions (Schröder 2007); instead, credit unions rely on the relationships they have with their customers. They offer continuity and reliability, for which their customers are willing to pay a premium. Savings banks are also hit less hard than commercial banks, and for similar reasons, but they are still hit harder than credit unions. Federal state banks (*Landesbanken*) are hit somewhat less hard by the crisis than commercial banks, but they restricted their lending to a greater extent than did savings banks and credit unions. Even though federal state banks are the umbrella association for all savings banks in their respective region, these banks invested excessively in risky assets prior to the crises and many of them experienced big problems during the financial crisis and had to restructure their balance sheets.

<sup>5</sup> Only firms with less than 1,000 employees are retained in the sample and used to calculate the credit constraint indicator.

Figure 3: Credit constraint indicator split by main bank



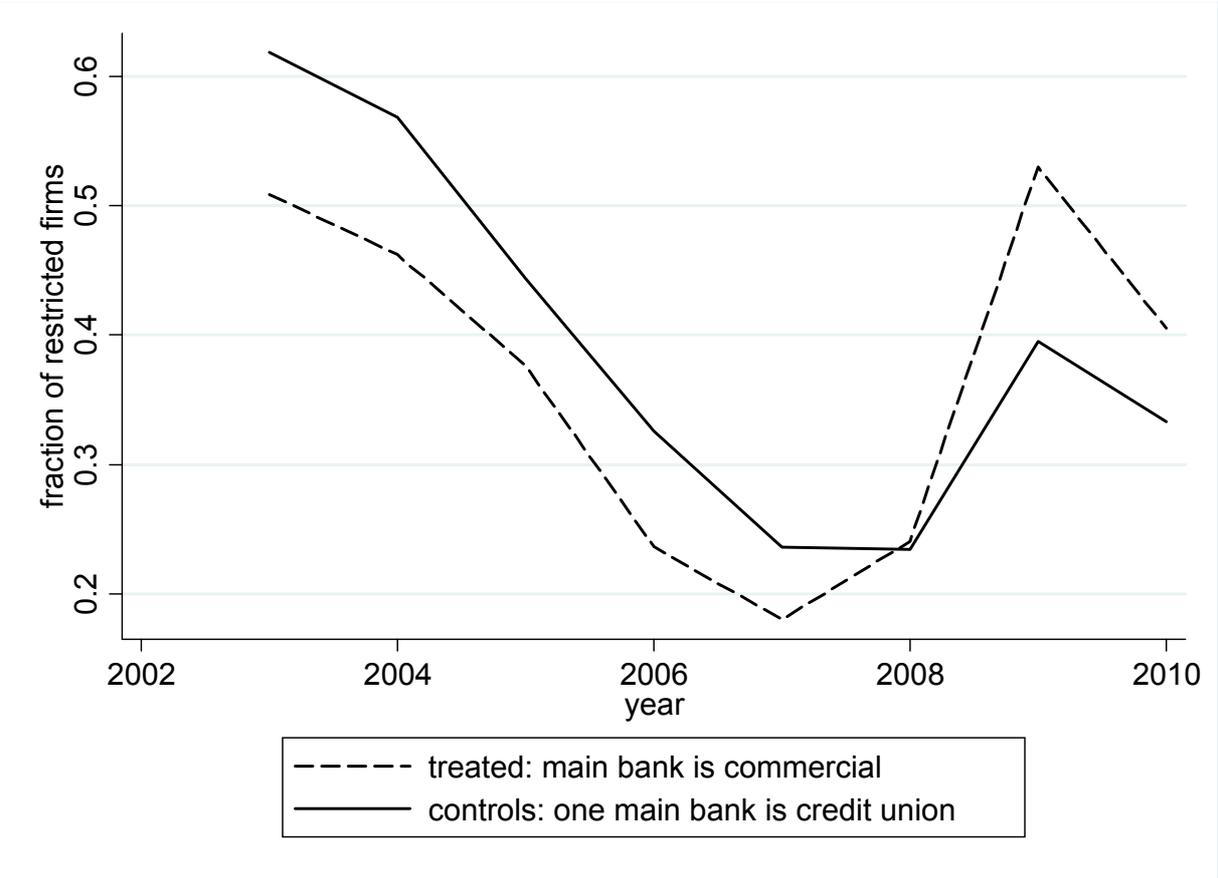
Source: Ifo Business Survey, own calculations based on 11,413 observations from 2,040 firms. Only firms with less than 1,000 employees are used.

All in all, there is clear variation in firms' access to credit depending on their main bank relation during the crisis. This phenomenon can be used to define a treatment group and a control group in order to capture a clear-cut difference in lending behavior caused by an exogenous shock. It is assumed that the reported main bank of firms remained unchanged during the whole period and we are confident in making this assumption as the main bank relation is by definition and by survey question wording a long-lasting relationship that does not change frequently.

The treatment group is comprised of those firms that report only a commercial bank as their main bank. These firms are not able to bypass the restrictive credit situation by relying on another main bank. They are also unlikely to be able to establish new relations with other banks during the crisis as banks in trouble will serve their existing customers first. If a firm is not able to obtain credit from its main bank during bad financial times, it is highly unlikely that it will find a new bank, with which it has no relationship, willing to provide credit. As the survey question about the main bank relation allowed multiple answers, i.e., firms could

report having more than one type of main bank, the control group is defined as those firms indicating that at least one of their main banks is a credit union. During and after the crisis, these firms can obtain credit from their credit union, even though their other main bank(s) might cut their credit lines.

Figure 4: Credit constraint indicator split by treatment group status



Source: Ifo Business Survey, own calculations based on 405 firms in the control group and 535 firms in the treatment group. Only firms with less than 1,000 employees are used.

Figure 4 graphs the credit constraint indicator split by treatment status.<sup>6</sup> The trend in both lines is parallel before the crisis hits. Firms in the control group, i.e., firms with a credit union among their main banks, always report a more restrictive lending situation before the crisis than do firms in the treatment group, i.e., those firms with a commercial bank as their main bank. When the financial crisis erupts, the lines close in on each other and ultimately cross in 2008. This is mostly because firms in the treatment group report a worsened lending situation, while firms in the control group report a nearly unchanged situation. Both lines rise in 2009, but the credit situation of the treatment group diverges even more from the control group.

<sup>6</sup>Again, only firms with fewer than 1,000 employees are included, thus ensuring common support across all size ranges for both groups.

## 6) Instrumental Variables Results

This section uses the different development of the lending situation faced by firms with credit unions and those with commercial banks as their main bank during the financial crisis to instrument the potentially endogenous reported restrictive lending variable in a difference-in-differences-like first stage. Formally, the following system of equations is estimated:

$$\text{1st stage : LENDING} = \alpha + \alpha_t + \beta_1 * X + \beta_2 * d + \beta_3 * d * I(t > s) + \varepsilon$$

$$\text{2nd stage : INNODISC} = \alpha + \alpha_t + \delta_1 * X + \delta_2 * d + \delta_3 * \overline{\text{LENDING}} + \varepsilon$$

where  $d$  equals 1 if a firm belongs to the treatment group; 0 otherwise.  $I$  is an indicator function taking the value of 1 if the year is  $s$  or larger; 0 otherwise. The time threshold  $s$ , after which the treatment group experiences the treatment, is the year 2007, which is the last year before the financial crisis started to unfold.  $\alpha$  is a constant and  $\alpha_t$  is a vector of time fixed effects. Columns 1 and 2 of Table 4 show the results. Column 1 reports the results without controlling for potential real economy effects; Column 2 includes controls for the demand situation, the state of business, and exposure to international trade in order to isolate the effects stemming from the financial system. After instrumenting the potentially endogenous lending variable and controlling for real economy effects, the effect must be interpreted as follows: facing restrictive bank lending leads to an increase in a firm's probability of discontinuing an innovation activity by 19.4 percentage points.

Table 4: IV Results

dependent variable: ...discontinued	(1)	(2)	(3)	(4)	(5)
	innovation			product innovation	process innovation
	RE	RE	FE	FE	FE
restrictive lending	0.181*** [0.0553]	0.194*** [0.0585]	0.216** [0.107]	0.224** [0.104]	-0.0115 [0.0685]
treatment group	0.0239*** [0.00520]	0.0242*** [0.00503]	-	-	-
not exporting	-	-0.00274 [0.0138]	0.0288 [0.0221]	0.0256 [0.0189]	0.001000 [0.00938]
demand situation	-	-0.0325** [0.0126]	-0.00452 [0.00402]	-0.00656 [0.00507]	0.00503 [0.00350]
state of business	-	-0.00348 [0.00494]	0.00235 [0.00856]	0.0115 [0.00821]	-0.0116** [0.00458]
state of business (expected)	-	0.0150 [0.00969]	0.00203 [0.00267]	0.000872 [0.00314]	-0.00559 [0.00425]
firm fixed effects	-	-	yes	yes	yes
observations	3544	3541	3541	3541	3541
number of firms	772	772	772	772	772
first stage					
treatment group*post-treatment	0.122*** [0.0253]	0.118*** [0.0246]	0.114*** [0.0230]	0.114*** [0.0230]	0.114*** [0.0230]
first stage F (excluded instrument)	36.70	34.79	24.7	24.7	24.7

2SLS estimation. Columns 1 and 2 report random effect models, Columns 3–5 report fixed effects models. Robust standard errors clustered at the “main-bank” level in brackets. Standard errors based on 1,000 bootstrap replications in fixed effects models; Fixed effects for year, industry, and size range included in all specifications. \*\*\* p<0.01, \*\* p<0.05, \* p<0.1

However, individual firm heterogeneity still might be driving the results. To rule this out, individual firm fixed effects can be added to the model. This leads us to estimate the following system of equations in which individual firm fixed effects are captured by the  $\alpha_f$ :

$$\text{1st stage : LENDING} = \alpha + \alpha_t + \alpha_f + \beta_1 * X + \beta_2 * d * I(t > s) + \varepsilon$$

$$\text{2nd stage : INNODISC} = \alpha + \alpha_t + \alpha_f + \delta_1 * X + \delta_2 * \overline{\text{LENDING}} + \varepsilon$$

The identified effect in the second stage, after taking care of firm heterogeneity by including firm fixed effects, is about 23 times larger than the one in the simple OLS model. Restrictive bank lending is associated with a 21.6 percentage point increase in the probability of discontinuing an innovation (Column 3). The effect seems to be mainly driven by the discontinuing product innovations (Column 4); the effect on discontinuing process innovations is small in magnitude and statistically insignificant (Column 5). This demonstrates that estimating the effect of restrictive lending on innovation by means of a simple OLS regression suffers from a huge endogeneity bias. Another reason for the discrepancy between OLS and IV could be measurement error in the restrictive lending variable, which is an admittedly crude measure. The IV identification strategy might isolate that part of the variation in the reported variable that is substantial.

The difference-in-differences-like first stage seems to provide a valid instrument for restrictive bank lending in all specifications. The coefficient of the interaction term between treatment group status and post-crisis period is highly significant and reasonably large in magnitude. Compared to firms having a commercial bank as their main bank, firms with a credit union as their main bank show a decrease in the probability of reporting a restrictive bank lending situation of around 11.5 percentage points during the crisis.

Some additional insights can be gained by applying the same methodology to different outcome measures.<sup>7</sup> Using the Ifo Innovation Survey, which is an even more detailed survey of innovation activity by German manufacturing firms, we can look at the effect of restrictive bank lending on the probability of *starting* an innovation. The Ifo Innovation Survey is conducted annually on a subsample of firms participating in the Ifo Business Survey. Using a measure from this survey sacrifices nearly half of all observations, which results in increased standard errors. The point estimate indicates that facing restrictive bank lending decreases the probability of starting an innovation by 37 percentage points. Unfortunately, this effect is insignificant due to the small sample size, but remains meaningful in its magnitude.

Moreover, firms may stop engaging in actual innovation activity, but apparently do not completely abandon the creative thinking process. When facing a restrictive lending situation, the probability of a firm having completed planning an innovation increases by 41.5 percentage points. This effect is mainly driven by completely planned product innovations while there seems to be no such effect for process innovations. There is no effect on the actual probability of introducing an innovation, which is as expected as innovations usually take quite some time to develop before they are introduced to the market.

All effects identified using this IV approach can be interpreted as causal under the assumption of parallel trends across groups in the absence of the treatment, meaning no additional group-specific shock, aside from the one stemming from the financial system, that influenced innovation activity of firms in the one group but not the other. Even though the assumption of parallel trends in the absence of treatment is by definition not directly testable, the next section contains several robustness tests providing evidence for the validity of the assumption.

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<sup>7</sup> Output omitted. Detailed results are available from the author upon request.

## 7) Robustness Checks

Estimating a difference-in-differences-like first stage is open to the claim that it is not a difference in the reported lending that is associated with the emergence of the crisis, but some simultaneously abrupt change in firm-specific or economy-specific variables. This could even lead to different effects of control variables pre and post crisis. To make sure that the model is not just picking up some real economy effects under a changing economic situation, but is actually capturing the effect stemming from the financial system, we re-estimate our IV model including interactions of all controls with the post-treatment period. By doing this, we can discover whether the identified effect is actually caused by the financial market crisis and not by some systematic jump in the importance of certain control variables at the treatment. Formally, we estimate the following system of equations:

$$\begin{aligned} \text{1st stage : LENDING} &= \alpha + \alpha_t + \alpha_f + \beta_1 * X + \beta_2 * X * I(t > s) + \beta_3 * d * I(t > s) + \varepsilon \\ \text{2nd stage : INNODISC} &= \alpha + \alpha_t + \alpha_f + \delta_1 * X + \delta_2 * X * I(t > s) + \delta_3 * \overline{\text{LENDING}} + \varepsilon \end{aligned}$$

This approach leaves only the variation of the LENDING variable explained by the instrument that is not already accounted for by any jump in influence of the control variables, such as the demand situation or exposure to international trade. The results of the estimation are shown in Column 1 of Table 5. The estimated effect of the LENDING variable in the second stage even increases compared to our baseline results, while the first stage remains highly significant. We could follow this approach to the extreme and include interactions of all covariates with the full set of year fixed effects in our model. Even in this setting, the instrumental variables approach holds, with a high F statistic of the excluded instrument and a virtually unchanged coefficient of the restrictive lending variable in the second stage, which remains highly significant (Table 5, Column 2). We also checked whether the estimations lead to different results for smaller firms. In a sample restricted to firms with fewer than 500 employees the results remain unchanged (Table 5, Column 3).

Finally, we are interested in excluding all firms that engage in no innovation whatsoever. In the Ifo Innovation Survey, firms report whether they consider innovation necessary. This measure contains information beyond the variable in the business survey that asks whether no innovations were planned for the period. There is a big difference between not intending to engage in innovation at all and not engaging in it because the firm is unable to do so at the present time. We can therefore exclude from our sample those firms that do not consider

innovation necessary to their business. Doing so does not change the results much. First, Column 4 of Table 5 provides the results using only the subsample of firms that answered the Ifo Innovation Survey and all the necessary questions in the Ifo Business Survey during the sample period. The estimated effects increase slightly compared to our full sample baseline IV effect, but standard errors also increase due to the smaller sample size. We lose more than half our observations and the effect loses significance. Nevertheless, the point estimate is of the same magnitude as before, so the insignificant coefficient is most likely due to small sample problems. Column 5 restricts the sample to those firms that did *not* rule out innovation activity because they considered it not necessary. In other words, the firms remaining in the sample are the ones that actually want to innovate. The estimated effect increases, as does the first-stage coefficient. Even though the differences are not statistically significant, we have the sense that restricting the sample to those firms that want to innovate strengthens the effect, as expected.

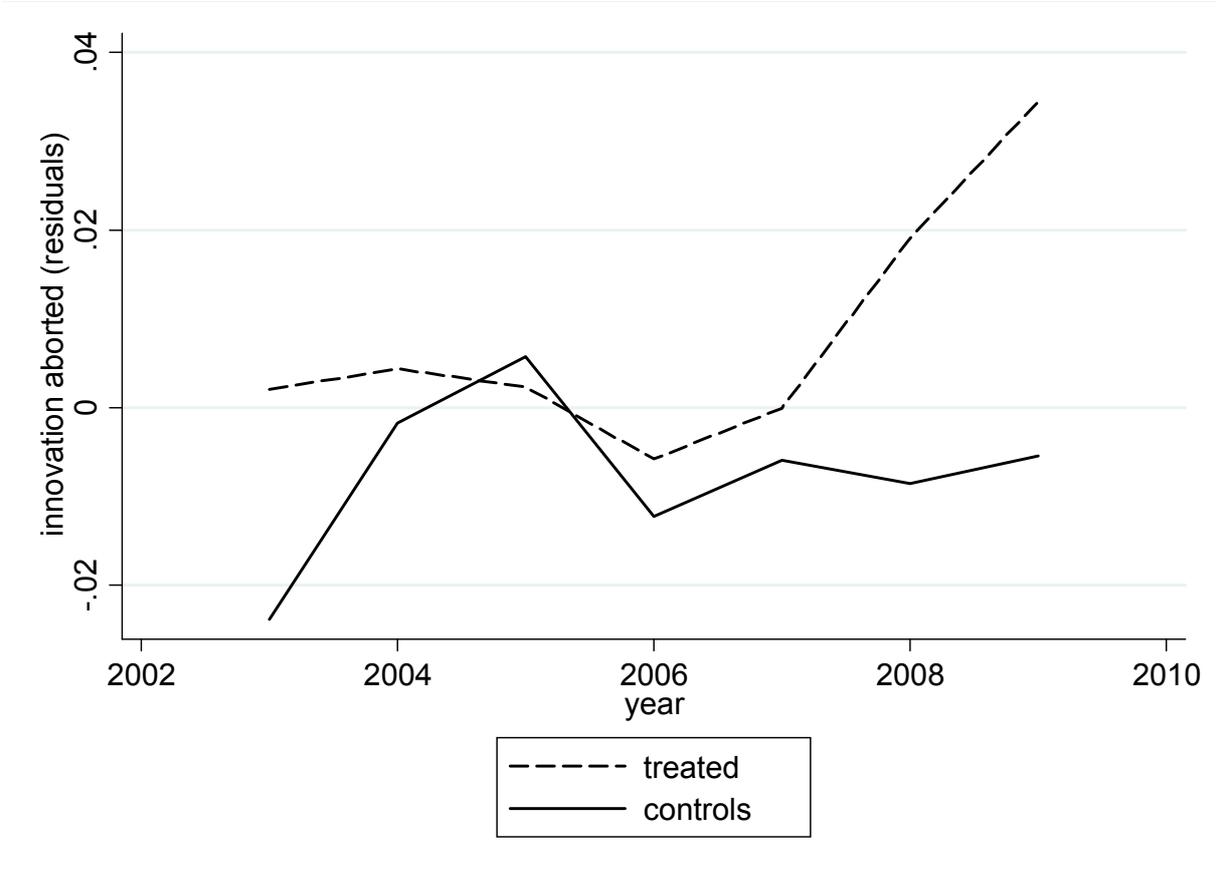
Table 5: IV robustness checks

	(1)	(2)	(3)	(4)	(5)
dependent variable:	full sample	full sample	under 500	innovation survey sample	innovation survey sample
innovation discontinued	full sample	full sample	employees	all firms	potential innovators
restrictive lending	0.503** [0.221]	0.517** [0.253]	0.296** [0.125]	0.366 [0.523]	0.405 [1.307]
not exporting	0.0399 [0.0349]	0.0383 [0.0319]	0.036 [0.0302]	0.0565 [0.260]	0.0171 [0.396]
demand situation	-0.00426 [0.00602]	0.0212* [0.0123]	-0.0124** [0.00509]	-0.00975 [0.0173]	0.00371 [0.0414]
state of business	0.0229 [0.0140]	-0.0198*** [0.00761]	0.00506 [0.0117]	0.0168 [0.0320]	0.0213 [0.0504]
state of business (expected)	-0.0106** [0.00430]	-0.0260** [0.0118]	0.00657* [0.00359]	-0.00264 [0.0201]	-0.0153 [0.0190]
interactions: X * post-treatment	yes	-	-	-	-
interactions: X * time dummies	-	yes	-	-	-
observations	3541	3541	3095	1501	1032
number of firms	772	772	692	482	389
first stage					
treatment group*post-treatment	0.0636*** [0.0148]	0.0598*** [0.0160]	0.112*** [0.0246]	0.122** [0.0439]	0.155** [0.0529]
first stage F (excluded instrument)	18.52	13.91	20.79	7.66	8.56

2SLS within estimation. Robust standard errors clustered at the “main-bank” level based on 1,000 bootstrap replications in brackets. Fixed effects for year, firm, and size range included in all specifications. \*\*\* p<0.01, \*\* p<0.05, \* p<0.1

For the IV approach to be convincing, the results should continue to hold in a reduced form setting. Figure 5 graphs the development of the final outcome, the discontinued innovation variable, for the treatment and the control group. It shows the residuals after controlling for time fixed effects, industry fixed effects, and size class fixed effects, as well as interactions of size and industry fixed effects with the full set of time dummies. What remains is the variation in the innovation discontinued variable that cannot be explained by such fixed effects and must be accounted for by other factors, such as the restrictive lending of banks.

Figure 5: Pre-treatment trends in “innovation discontinued”



Source: Ifo Business Survey waves 2003-2009.

With exception of the year 2003, the first year in our sample, we recognize a quite similar pattern before 2008 and a diverging development afterwards. Based on this graphical evidence, we are confident that the difference-in-differences setting is appropriate for this context. Formulated in a regression, we can estimate the reduced form to verify the approach. Results are shown in Column 1 of Table 6. The significantly positive coefficient in Column 1 is interpreted as follows: having a commercial bank as one’s main bank increases the probability of discontinuing an innovation by 2.96 percentage points during the recent

financial crisis in comparison to firms having a credit union as their main bank. These results are in line with our findings in the instrumental variable setting.

*Table 6: Reduced form, IV first stage and placebo treatments*

dependent variable:	(1) innovation discontinued (reduced form)	(2)	(3) restrictive lending (IV first stage)	(5)
treatment group * post-treatment period	0.0296*** [0.00704]	-	0.0598*** [0.0160]	
treatment group * year 2003	-	0.00994 [0.0151]		-0.00223 [0.0268]
treatment group * year 2004	-	-0.0172 [0.0138]		-0.0569 [0.0374]
treatment group * year 2006	-	0.00426 [0.0115]	-	0.000543 [0.0224]
treatment group * year 2007	-	0.00713 [0.00927]	-	0.0424 [0.0262]
treatment group * year 2008	-	0.0278 [0.0162]	-	0.0273 [0.0241]
treatment group * year 2009	-	0.0338** [0.0121]	-	0.0945*** [0.0199]
not exporting	0.000961 [0.0184]	0.0679* [0.0370]	-0.0670 [0.0456]	-0.00855 [0.0537]
demand situation	0.0119 [0.00681]	0.0322** [0.0135]	-0.0197 [0.0414]	0.0750* [0.0341]
state of business	-0.0303** [0.00957]	0.00711 [0.0153]	-0.00550 [0.0267]	-0.0709*** [0.0146]
state of business (expected)	-0.00643 [0.00456]	-0.0213 [0.0267]	0.0183 [0.0384]	-0.0395 [0.0377]
interactions: X * year fixed effects	yes	yes	yes	yes
observations	3692	3692	3541	3541
number of firms	785	785	722	722
R-squared	0.04	0.041	0.151	0.183

OLS estimation. Robust standard errors clustered at the “main-bank” level in brackets. Fixed effects for year, firm, and size range included in all specifications.

\*\*\* p<0.01, \*\* p<0.05, \* p<0.1

For the difference-in-differences setting in the first stage to be convincing, we need to assume similar trends across groups in absence of treatment. By definition this assumption is not directly testable. However, we can use the panel structure of the data and look at pre-treatment trends for an indication of the validity of this assumption. Because the variation used for identification in this paper comes from a group-specific jump at one point in time, in this special setting we actually want to have similar pre-treatment trends in both the outcome variable and the instrumented variable. We further need to check for the correct timing of the treatment period.

Figures 4 and 5 provide first evidence that the parallel trend assumption holds as well as for the correct timing of the treatment period. Additionally, we can estimate a regression that includes all possible placebo treatment dummies. To support the treatment period used in this paper, all placebo treatments before the actual treatment period should be insignificant. Table 6 shows the placebo treatments specification results for both the reduced form (Column 2) as well as the actual first stage used in the IV approach (Column 4). For both we estimate the basic specification with the aggregated treatment effect starting in 2008 for comparative reasons (Columns 1 and 3) and the placebo treatment specification including all interactions between the treatment group and the complete set of year dummies (Columns 2 and 4). All specifications include interactions between all control variables and the full set of time dummies to leave only that variation of the outcome variable to be explained by the treatment group interactions not already accounted for by any changing influence of the control variables over time.

If the treatment period is chosen correctly and the influence of the treatment is substantial, the coefficients of the interaction terms should be significant only during the treatment period. For both the reduced form (Column 2) and the actual first stage (Column 4), there is a clear tendency in the significance of the interaction terms beginning in the year 2008, with the most substantial effect in 2009. This ensures us that the difference-in-differences setting in the first stage is appropriate. The variation identified by the interaction term between the treatment group and the post-treatment period is indeed substantial and the timing fits the emergence of the financial crisis.

## 8) Conclusion

Does restrictive bank lending result in reduced innovation? According to the results of this paper, the answer is “yes.” Using differences in the lending behavior of commercial banks and credit unions during the financial crisis as an instrument for restrictive bank lending at the firm-level indicates that a relatively short period of financial distress can have important implications for long-term growth.

This paper exploits an institutional feature of the German banking system, which is divided into three pillars: commercial banks, credit unions, and savings banks. Each pillar was affected differently by the financial crisis due to differences in their business practices. Based on information about the strong and stable main bank relation of the firms in our dataset, this paper utilizes the fact that the ability of a firm to raise external debt is affected proportionally to the degree its main bank is affected by the financial crisis. Commercial banks were hit very hard by the financial crisis, had huge difficulties in refinancing themselves on the interbank market, and had to reduce their loan originations; credit unions, on the other hand, were comparably unaffected by the crisis. Their high deposits-to-assets ratio and their predominant focus on the regional market saved them from disaster. Using this as exogenous variation in the availability of external debt solved the endogeneity problem usually found when using the usual ordinary least squares estimator. The difference-in-differences-like first-stage regression is robust and strong and the instrument, constructed from a firm’s bank relation with a commercial bank as opposed to a relation with a credit union, appears to be valid.

A simple OLS model significantly underestimates the effect of restrictive bank lending on innovation, which indicates that endogeneity problems are pronounced in this setting. The results of the IV approach show that when facing a restrictive lending situation, firms are 21.6 percentage points more likely to discontinue an already ongoing innovation activity. Product innovations are especially prone to discontinuation whereas there seems to be no such effect for process innovations.

Discontinuing an innovation implies sunk costs for the firm as well as for the economy as a whole. Furthermore, it inhibits future growth and future international competitiveness. Even a relatively short period of restrictive bank lending can lead to the discontinuation of innovation projects. This fact has to be taken into account by any politician or international organization dealing with a financial crisis as it implies that there will be additional negative long-run consequences of the crisis on top of the current, prominent effects.

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